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PAPERS AND PROCEEDINGS OF THE 1951 ANNUAL MEETING — Part III

THE ROLE OF THE INSECT IN CIVIL DEFENSE

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Dr. Taliaferro asked me to address you in his place since as many of you know, he has been concerning himself more and more with problems of immunity and has practically ceased any investigations on parasites. I personally am more interested in the parasites and certain of their effects on the host than I am in the control of arthropod vectors. However, I hope that some of the ideas I shall try to present will be germane to the interests of the present conference.

The question of the possible role of insects in Civil Defense can be resolved into four major points.

First, we must consider the insect vectors and the diseases already present in the area under study.

Secondly, we must examine the possibility that rare or sporadic disease transmission may evolve into epidemic spread under the conditions following an attack either high explosive or atomic in nature.

A third factor to be considered is the possible introduction of new or more virulent agents of disease by biological warfare methods.

Finally, we have the possible alteration of known epidemic patterns by atomic warfare.

After a bombing attack, whether atomic or high explosive, we can expect and prepare for a series of events of importance in disease transmission.

There will be movement of groups of people and massing of refugees from the afflicted areas. Thus we will have large numbers of people in close personal contact.

We can expect immediate partial or total destruction of sanitary facilities associated with water supply and waste disposal.

There will be an overloading of these same sanitary facilities in areas of refuge.

As a fairly immediate result we can also expect increased breeding of flies and mosquitoes in areas bombed as well as an increase in rats, which may act as important reservoirs of human disease.

Almost at once one might expect increases in food- and water-borne typhoid, the bacillary dysenteries and amoebic dysentery. The primary controls necessary to prevent these enteric infections from becoming epidemic center about the re-establishment of general sanitary conditions.

Insect control, although important, is secondary to these primary control measures. The control of the so-called "filth flies" will be necessary to eliminate the possibility of epidemic insect borne enteric infections.

A potential danger of probably less importance will be the increase of culicine mosquitoes. The virus encephalitides, specifically St. Louis encephalitis, might be transmitted in epidemic proportions. Thus, general mosquito control measures must be sustained.

Increase in anopheline mosquitoes would probably be of no immediate consequence. In most areas of the United States no extensive endemic reservoirs of malaria are to be found. Thus a high infection rate is extremely unlikely over any short period of time.

With redistribution of a refugee population and overcrowding that may result, another danger—louse-borne or epidemic typhus—may present itself. It is difficult

to assess the danger from this source. As shown by sporadic cases of Brill's disease in our larger cities we may assume that there may be a constant low level of infection in the population at large. In any case, experience during the last war has shown that epidemic typhus can be controlled even when in full stride. Extensive louse control measures can be postponed until there is evidence of marked increase in human louse infestation or increase in typhus itself.

Another important epidemic disease might follow an increase in the rat population—that is, bubonic plague. Where reservoirs of infection are known to exist as in some of our west-coast areas, transmission of the disease to man by rat fleas could occur on an epidemic scale. This would, in all probability, necessitate first an epidemic in the rat population. Rat control rather than insect control would be the most effective measure.

The question of the use of infectious agents in biological warfare and their possible relationships to insect-borne disease is obscured by the restriction of information by the armed forces. However, of the dozen or more disease agents that might be most effectively used, few would be primarily related to insect transmission. The enteric group such as cholera or typhoid would be primarily water-borne—and only secondarily transmitted by "filth flies." Such forms as bubonic plague or even the rickettsial group might be used. Although these are primarily arthropod-transmitted under natural conditions, they can also infect via the respiratory tract and most probably would be disseminated as aerosols. Once established in the population, insect transmission might later be of importance and necessitate control.

One can go to the realm of fantasy in imagining what insects might possibly be used for nuisance value in a protracted attack. Less fanciful perhaps, might be the introduction of strains resistant to insecticides or new forms injurious to plants and livestock. If we consider the difficulty in handling large numbers of insects in this way I think we can assume they are low on the list of practical biological weapons.

Finally there is the additional point that epidemic patterns of some diseases may be changed by atomic warfare. Not only may there be greater destruction but if large groups are exposed to radiation an epidemic may run an extremely rapid course in a susceptible population with its general immunity lowered by radiation damage.

MOSQUITO CONTROL ACTIVITIES OF THE COMMUNICABLE DISEASE CENTER, U. S. PUBLIC HEALTH SERVICE

GEORGE H. BRADLEY AND F. EARLE LYMAN

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The program for eradication of malaria from the continental United States continues to be the principal mosquito control activity of the Communicable Disease Center. This program was begun on July 1, 1947, and is carried on cooperatively with state health departments throughout the southeastern United States.

At the present time, the goal of the program—eradication of malaria as a disease of public health significance in this country—appears to be rapidly approaching.

Widespread use of DDT residual house spraying for malaria control was begun in this country in 1945, and approximately 700,000 house spray applications were

made in that year. The peak of activity was reached in 1948, when spray was applied in over 1,300,000 homes, in 360 counties of 13 states, at a cost in federal, state, and local funds of approximately $5,000,000. The annual number of houses treated thereafter declined to about 1,000,000 in 1949, and to 842,000 in 1950. A six-year summary (1945–1950) of entomological evaluation of the program, based upon a total of 77,600 inspections of sprayed and unsprayed houses, indicates that 98.5 per cent of the sprayed houses were maintained free of *Anopheles quadrimaculatus*. In comparison, only 86.7 per cent of unsprayed houses were free of these mosquitoes; thus, control was approximately 90 per cent. There has been no indication of the development of resistance to DDT in *A. quadrimaculatus* such as has been encountered with houseflies, and also reported for some mosquitoes. In 1950 the percentage of sprayed houses kept free of *A. quadrimaculatus* was approximately the same as in 1945.

With the present low incidence of malaria in this country, it does not appear that the expenditure of further large sums on widespread malaria control activities will be necessary. In 1950, it is estimated that only 2,200 cases of the disease will be reported for the entire country as compared to 62,763 in 1945. Of 671 cases supposedly of malaria which were carefully appraised in southeastern states during 1950, only 26 proved to be parasite-positive, and of these 26, only 6 were judged to be new cases originating within the United States. In spite of this encouraging situation, however, it is deemed advisable to proceed with caution in terminating malaria control activities. We want to feel absolutely certain that the disease will not recrudesce. Hence, in accordance with the long-range plans set up at the start of the eradication program in 1947, and to fulfill the Malaria Eradication Criterion recently established by the National Malaria Society, the Communicable Disease Center is now organizing a Malaria Surveillance and Prevention Program. The National Malaria Society's criterion is that "Malaria may be assumed to be no longer endemic in any given area when no primary indigenous case has occurred there for three years, if reporting and case finding are actively promoted and adequate investigations are carried out."

On the Surveillance and Prevention Program it is proposed, insofar as C.D.C. personnel are available and are needed to supplement state personnel, that epidemiologists, entomologists, and engineers will be assigned to work in cooperation with the health departments in the thirteen southeastern states to find and eliminate malaria wherever it may still be found, and take steps to prevent its reestablishment. The plan calls for the epidemiologist to investigate and appraise all regularly reported malaria cases, as well as others that may be uncovered by inquiry, and to determine the validity in each instance. Whenever a parasite-positive or clinically consistent case of malaria is located, appropriate treatment will be provided and the indicated anti-anopheline measures carried out. Other duties of the surveillance and prevention teams will include assistance in typhus control and other programs for the prevention of insect-borne diseases. The study by Mr. D. C. Thurman on mosquito dispersal in California, which will be reported on later at these meetings, is an example of this incidental work, as is a surveillance program being carried on in South Florida to detect any tendency for *Anopheles albimanus* to migrate northward.

Another phase of the antimalaria work of the Center is being carried on at three malaria investigation stations located in previously hyperendemic malarious areas at Manning, South Carolina; Newton, Georgia; and Helena, Arkansas. At these stations, close observations are being made on many factors related to the natural occurrence of malaria, in an attempt to detect as far in advance as possible any recrudescence of the disease, as well as to attempt to discover explanations for the present recession. Thick-film blood surveys are made periodically of all residents

in one of the study areas. In the two other areas, careful evaluations of all reported illnesses are made, and any person having clinical symptoms of malaria is carefully examined to determine if he actually has the disease. It may be of interest to this group to know that the last malaria epidemic of record in this country occurred in the vicinity of Manning, South Carolina, in 1944. A rapid decline in incidence followed, and no positive cases have been found in the area since February 1949.

Another activity of the Center which involves mosquitoes is concerned with encephalitis. Investigations are being carried on which are aimed at obtaining a more intimate knowledge of the role of mosquitoes in the over-all epidemiology of the disease, as well as the part played by other arthropods and the higher-animal reservoirs. The biologies and habits of potential mosquito vectors of the disease are being carefully studied in order to obtain information on which to base practical control procedures. Headquarters for these investigations in the East are at the Virus Laboratory of the Center in Montgomery, Alabama; in the Central States, at the Office of Midwestern CDC Services at Kansas City, Kansas; and in the far west the work is carried on cooperatively with the Hooper Foundation for Medical Research of the University of California, with headquarters at Bakersfield, California.

An increasingly important activity of the Center is related to the development of the water resources of the nation. One phase of this work is aimed at preventing the creation of conditions conducive to the production of mosquitoes on reservoirs and impoundments. In cooperation with the Corps of Engineers, Department of the Army, the Center during 1950 prepared survey reports covering recommended antimosquito measures for consideration in the construction of 46 reservoirs in 18 states. These bring to a total of 240 the number of reservoirs for which similar survey reports have been prepared since 1945.

Throughout the Missouri River Basin, mosquito problems in relation to impoundments and irrigation practices are being studied by a group of Center workers with headquarters at Kansas City. We are participating with other Federal and State agencies in making surveys to determine present and potential mosquito problems, and methods for their prevention, in connection with the work of the Federal Inter-Agency Water Resources Committee. At present, this work is under way in the northeast in the river basins of the New York-New England area, with headquarters at Boston, Massachusetts, and in the Arkansas-White-Red River basins, with headquarters at Little Rock, Arkansas.

At the Savannah, Georgia, Laboratory of the Center a variety of investigations on mosquitoes is under way. These have to do chiefly with the development of improved approaches to control. This work will be discussed by Dr. Archie Hess at a later session of this conference.

Any discussion of mosquito activities of the Center would not be complete at this time without some mention of the trend in present-day thinking in the Public Health Service relative to the interests of health agencies in mosquito control work. In a letter to regional and state health officials which discussed Service policy relating to disease vector and other mosquito control on water resources facilities, the Surgean General states: "It is our conviction that pest mosquitoes should receive more attention from health authorities than they have in the past. Public health is something more than the absence of disease. Physical efficiency and comfort, on which mental equanimity depends to a substantial degree, may be seriously disturbed by the continued annoyance of pestiferous mosquitoes which may or may not have disease-transmitting potentialities."

It is also true, of course, that with the ever-increasing fund of our knowledge concerning the relation of mosquitoes to disease, many mosquitoes, traditionally of

importance from the standpoint of annoyance alone, are now coming to be labeled as potential transmitters of diseases. The distinction between "disease vector" and "pest" mosquitoes thus is fading. In view of these developments, health authorities may be expected to take an added interest in pest mosquito control programs. By so doing, knowledge and effort of all parties concerned with mosquito control may be pooled, to the end that more pleasant as well as more healthful environmental conditions may be established throughout the country, with a concomitant promotion of greater national well-being.

NAVY RESEARCH AND CONTROL OPERATIONS

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The United States Navy is vitally interested in, and active in the study of problems related to insect disease vectors in general and mosquito control measures in particular. The necessary location of many Navy establishments is based on topographical features, geographical requirements, harbor facilities and other basic factors. Since most of these conditions which are valuable to naval operations are accompanied by positive ecological situations conducive to extensive insect breeding, it is elementary to understand the reasons for naval insect control interests.

Screening the research reports of studies completed or continued, the following were chosen as examples of Navy activity in problems which are important to us during these meetings.

During 1950, considerable information was prepared at the national Naval Medical Center, Bethesda, Maryland, and reported as "Observations on the Experimental Transmission of Japanese Encephalitis by Mosquitoes" and "The Propagation of Japanese Encephalitis Virus in the Mosquito by Parenteral Introduction and Serial Passage." At the same time conspicuous "Observations on the Preerythrocytic Stages of *Plasmodium relictum, P. cathermerium* and *P. gallinaceum* in various Birds" were conducted.

The taxonomy of the mosquitoes of certain strategic localities of the world has continued through 1950. "Mosquitoes of the Eastern Carolines and the Philippines" is now completed. A report of "Alaskan Mosquitoes" is in press. Navy taxonomists are now engaged in similar studies at the Naval Medical Research Unit #3 in Cairo, Egypt, where "Taxonomy of Mosquitoes of the Middle East" is in preparation.

Personnel at the Naval Medical Research Institute are also engaged in a study of the "Effects of Larval Population Density on Behavior of Adult Mosquitoes" and "Sulfonamides as Factors in Increasing Susceptibility of Mosquitoes to Parasitic Invasion (*Plasmodium gallinaceum*)."

The work in the Naval Medical Research Unit #3 in Cairo has developed very rapidly in the short time this Unit has been established. Reports on the achievements of this outstanding naval unit are being made available through popular and scientific publications. "Biology and Control of Houseflies in the Middle East" is a record of significance. Described in this report are the results of extensive studies of seasonal fly populations which exhibit the great importance of temperature to the definite annual population curve. In Cairo, too, rapid development of DDT resistance was

noted. This resistance appeared more quickly than in some areas of the continental United States, probably due to the large breeding areas where many generations produce large fly populations. In brief, the reports of the Naval Medical Research Unit #3 show that in late 1947, the failure of DDT was easily recognized. A change to BHC in 1948 showed excellent results but in 1949 this chemical had produced resistant populations. In the spring of 1950, field studies showed that chlordane provided very efficient controls. However, it is believed that resistance to this chemical is to be expected. Interesting to repeat from almost all reports is the thought that the use of chemical insect control does not excuse inefficient sanitation.

This reporter is hopeful for the continued successful investigations of sandfly habits and controls which are being conducted in the Yemen area. And a recent research problem concerning the "*Culex pipiens* complex in the Mediterranean Area" will give you an insight into the broad scope of the important work by NAMRU #3.

The U. S. Navy Epidemic and Disease Control Unit #6 is starting an intensive research program which is aimed at "Filariasis and Its Control in Islands of Central Pacific" which will no doubt tie in with the Naval Medical Research Institute's "Studies of Filariasis and Its Control in Samoa." This Navy Epidemic and Disease Control Unit #6 was established at Pearl Harbor in 1949 and provided the basis for the first insect control operations in the Korean episode in its early stages last year.

Our Naval Medical Field Research Laboratory, Camp LeJeune, North Carolina, made numerous practical studies during 1950. The "Evaluation of Two Hand-operated Larviciding Sprayers" led to numerous important changes in manual mosquito control equipment and the "Design for an Easily Stacked, Light Weight Durable Hand Dipper for Mosquito Survey" has been of utmost value to the work of field surveyors.

Space sprays, cockroach control, insecticide evaluation, container corrosion prevention and specification tests are among other miscellaneous studies which are under way at offices like the Naval Industrial Test Laboratory, Philadelphia, and at other Federal agencies. Some of the above listed research reports are the result of cooperation from or collaboration with the U. S. Department of Agriculture, the U. S. Public Health Service and others. The work of these Navy specialists is well coordinated with U. S. Army and Air Force studies for the elimination of duplication and the mutual benefit of the armed forces. However, most of these studies are not classified and are already published for use by all control workers.

My subject also includes a brief of control operations which I am going to limit to mosquito control in the Sixth Naval District. The U. S. Malaria and Mosquito Control Unit #1 is the agency responsible for most of the insect control activity in this area of seven southeastern states. Although its laboratories and offices are at the Naval Air Station, Jacksonville, Florida, this Unit carries on its functions from Charleston, South Carolina to Key West, Florida, and west to Memphis, Tennessee. Permanent control measures are the basic interests of this Unit and mosquito control sanitation is stressed in every program at the various naval stations served. Excellent cooperation from state, county and city health authorities is reported from each area. Drainage and ditching operations develop slowly and require time for completion. The largest single permanent project is now being inaugurated in the Key West area. Extensive naval activity in this area has necessitated the redevelopment of a large project which was started in 1942. This project will require about two years to complete; it has the backing and cooperation of state, county and city commissioners and will establish an all-important annual maintenance program.

To augment all permanent control plans, intensive and extensive temporary

control measures are under way. Fog machines and sprayers are located on all the reservations and their operators are assisted and advised from this Unit. Airplanes for aerial spraying are located at Jacksonville, Key West and Memphis.

Although 1950 was one of the worst mosquito seasons in some areas, in others there was little or no problem. Where 5 per cent DDT solution (.3 lb. DDT to the acre) failed to produce effective results, the addition of 2 per cent lethane (by volume) or on occasion small amounts of piperonyl butoxide—pyrethrum solution renewed the efficiency of the operations.

The Unit has continued work on the development of automatic insecticiding equipment for use on aircraft. This equipment was described at the American Association of Economic Entomologists' meetings at Denver last December. It provides for the simultaneous insecticidal treatment of all areas of the airplane with the required dosages. Large scale installations are being made in modern hospital evacuation planes (C54M) used by the Military Air Transport Service for the delivery of troops and cargo from the United States and the return of casualties to the United States. Automatic timing devices allow for "super" dosages for the control of agricultural pests while "normal" dosages are produced for the eradication of more susceptible insects of public health importance. It is, therefore, the best protective device against the possibility of introduction of foreign insect species. The sealed counter indicator will record treatments and can be used by Quarantine inspectors as evidence of proper treatment.

This project receives the utmost cooperation from the Department of Agriculture, Public Health Service and other federal agencies.

During 1950, several new insecticide formulations found listings as Navy Standard Stock items. A 2 per cent chlordane solution received wide use on many naval stations. The item "Standard Navy Insecticide" was changed from 10 per cent lethane to 5 per cent lethane with 3 per cent DDT added. This item has rapidly proved its worth in Navy insect control and is recommended for consideration where DDT is scarce and where DDT has become inefficient.

Control operations have become more effective and less expensive with the improvement of equipment, materials and techniques.

During the 1950 period, this Unit was responsible for the operation of more than 5,000 light traps. The contents of these traps included more than 40 species of mosquitoes which totalled over 70,000 specimens. Much of the control work is based on adult mosquito population index and the value of these studies to our more or less remote control measures is not to be underestimated. The use of synoptic and local weather reports, the routine ground surveys and the analysis of the adult population studies provides basis for efficient adulticiding and larviciding.

Recent assistance in soil conservation service studies is proving valuable in reducing breeding in some areas of impounded waters. This service is recommended because of its importance in all conservation programs and because it can be had at no cost.

Training is an ever present necessity in any progressive plan of operation. The Malaria and Mosquito Control Unit #1 serves as training center where naval reserve entomologists and malariology technicians may come for annual two-week periods. Illustrated lectures, practical demonstrations and experience-education are made available to these reservists. In return they bring to the Unit extensive reports of many areas and the practices peculiar to those sections. Thus mutual benefit to all is provided at little cost.

The outlook is optimistic as our research and control operations continue. With the cooperation of many federal, state and local agencies in interested groups, a close integration of methods and controls are in the plans for the coming season.

CONFLICT WITH CULEX

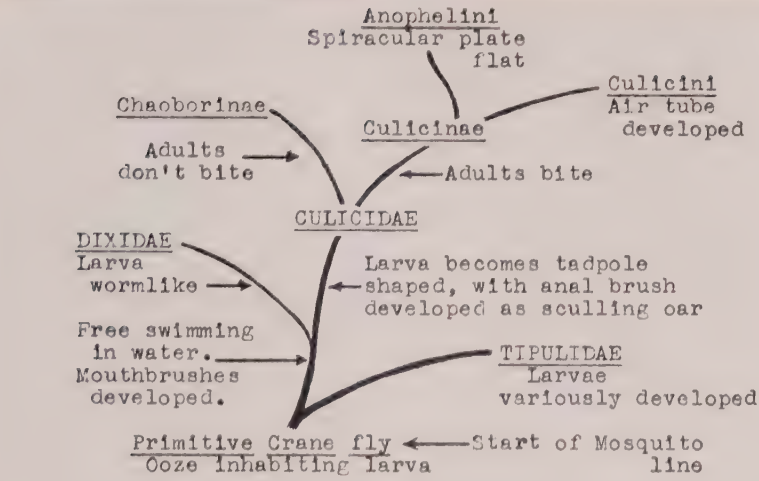
HERBERT H. ROSS
Illinois Natural History Survey, Urbana, Illinois

In the last 20,000 years man has changed from a primeval and possibly rare subtropical animal to his present condition as a widespread and a dominant species inhabiting the greater portion of the earth's surface, and having a complex and gregarious social structure. The increasing complexity of this social structure is a function of large and increasing population. This in turn has been achieved essentially by man's greater and greater ability to change various factors of his environment and make it better suited for his own survival and increase. Man ploughs natural prairie or cuts forests, and grows in their place plants such as corn or cotton which furnish greater quantities of food or material than the natural plants of the area. He makes clothes and builds heated houses, enabling him to live in colder areas than those to which he is naturally adapted. He collects water and redistributes it for irrigation or power. All this spells environmental control and it is a fair guess that he has so far only begun on a much longer path.

It is a paradoxical fact that every change that benefited man also benefited a host of insects. When succulent crops were planted together in fields, when grain was stored in quantity, when animals were brought together in flocks, some species of insects found these conditions irresistible and moved in for the feast. As a result man has been battling insects ever since he has consciously been bettering himself.

These pests we have mentioned classify as opportunists, who were of no direct hindrance to man before he started along the road to environmental control. There are pests belonging to another class, those such as beasts of prey, biting insects, and diseases, which were enemies of primeval as well as civilized man. The beasts of prey were originally the starkest enemy of man but are now under fairly good control. What of the insects? It seems certain that primeval man must have suffered just as much from biting insects as we do now. How he fared with insect borne diseases is a matter of conjecture. But it is certain that as human populations increased, they became more and more vulnerable to epidemics of insect-borne diseases, including the important ones carried by mosquitoes. This is a problem in areas which we have already cleared and subjugated. But there is another one. There are hundreds of thousands of square miles of country where the tremendous abundance of mosquitoes and other blood sucking flies has discouraged real development by civilized man, either for habitation or for the more efficient production of foodstuffs needed for expanding populations. There is a challenge here to control a facet of an environment before the environment as a whole can be controlled. So whether the battle is old or new, man finds himself engaged in a full-fledged conflict with Culex.

I have heard many people ask about this enemy "Where did it come from, how did it get started, why are there so many kinds of them?" and it started me to wondering also. People have studied the evolutionary history of elephants and extinct dinosaurs, but what about this much more important member of man's environmental resistance, the mosquito? How much do we know about the early history of this group and the evolutionary factors which led to their extremely abundant development? There is little about this in the literature and so a search was begun for information which would bear on this question. Fossil evidence gives few clues to the problem and it has been



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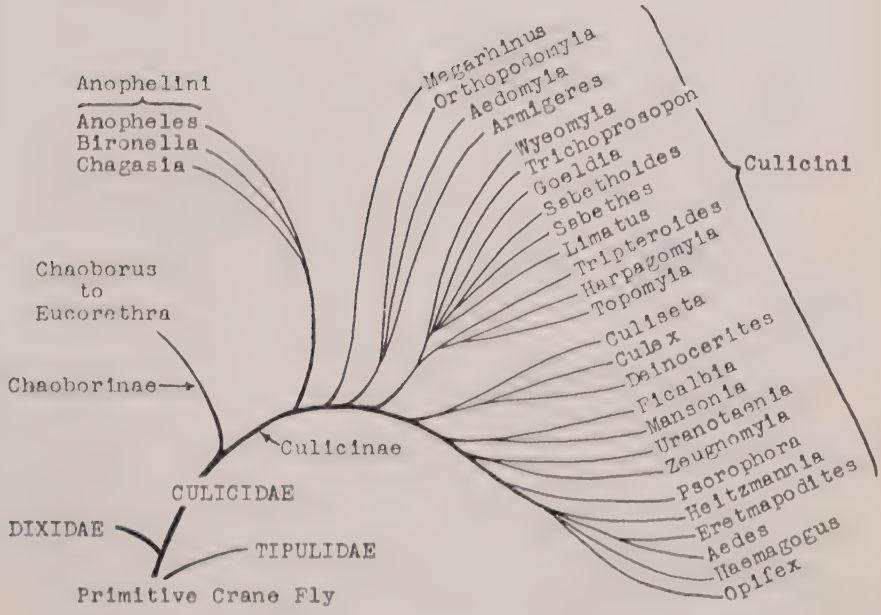

B.

FIG. 1. A. Phylogenetic tree illustrating the relationships of the Culicidae. B. Phylogenetic tree of the Culicidae, illustrating relationships of most of the genera.

necessary to piece together many bits of evidence from comparative bionomics and morphology. Gradually a picture has started to emerge and I would like to give you the highlights of a progress report.

The story of basic mosquito evolution is chiefly shown in the larvae. Adults and pupae have corroborative evidence, but the main line of adaptive developments has been for larval life. As we trace back down this line, Fig. 1(A), it is clear that the mosquito invented no really new structure but simply remodeled and improved parts that had already come into existence in previous groups. This is true not only of larval structures but also of the piercing-sucking mouthparts of the adult mosquito.

The base of the mosquito line, Fig. 2, starts with a primitive crane fly, in which the larva was wormlike and practically aquatic. Its mouthparts were generalized, and its spiracles had some sort of floats to keep them at the surface of the water for breathing. The next step upward was the adaptation of the mouthbrushes for feeding on surface organisms, as we see in the Dixidae, correlated with free aquatic existence. This was followed by a dual development which produced a swimming rather than a wriggling larvae: (1) the expansion of the thorax and slenderizing of the tail, and (2) the de-

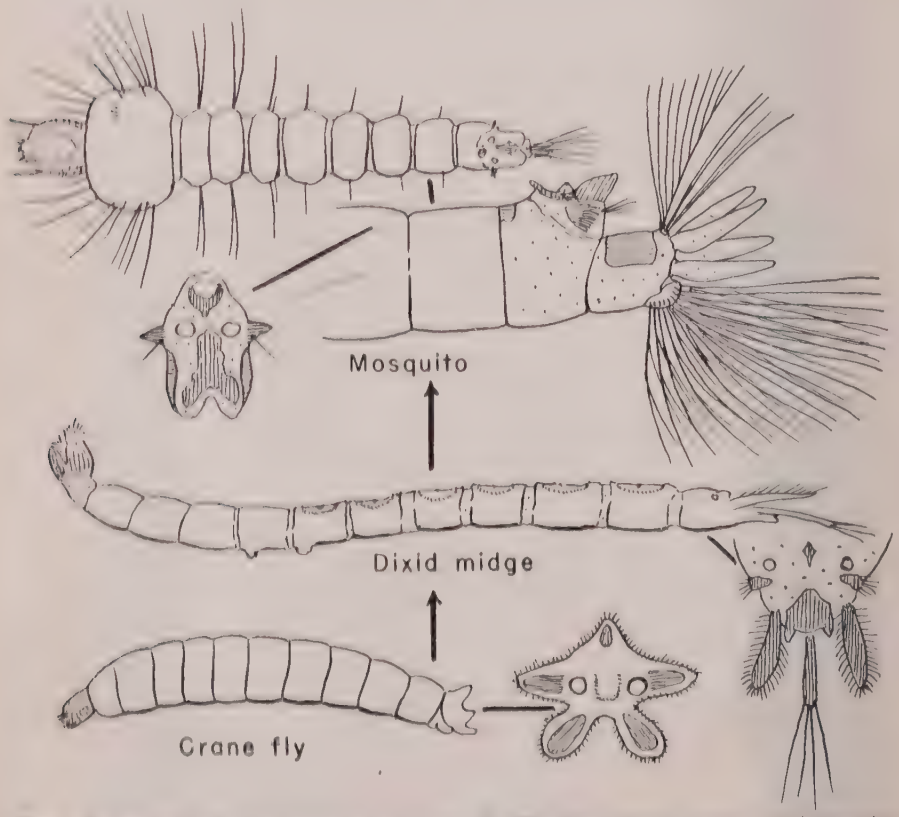

FIG. 2. Larvae and spiracular apparatus of a crane fly (Tipulidae), dixid (Dixidae), and mosquito (Culicidae), illustrating steps in the evolution leading to the mosquito.

velopment of the anal brush of hairs which acted as rudder and sculling oar. This stage is shown perfectly in *Eucorethra,* of the Chaoborinae. Thus at this point we have a full fledged mosquito larva, but the adult does not bite.

This introduces the next stage. The adult developed piercing-sucking mouthparts, simply by an elongation and slenderizing of parts already present in the more primitive forms. Thus the first true mosquito came into being, still retaining the surface feeding larva. The

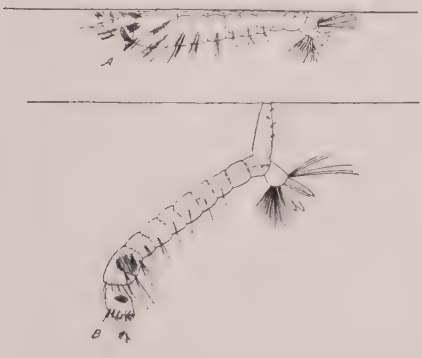

Fig. 3. The two principal types of mosquito larvae. *A,* Anophelini (without spiracular tube); *B,* Culicini (with spiracular tube). (After King, Bradley, & McNeel.)

genus *Anopheles* is very little changed from what this original ancestor must have been, so little that the genus is in reality a living fossil, at least 70 million years old, but certainly a highly successful fossil.

The next step was the development of a tube for the spiracular openings, Fig. 3. This enabled the larva to hang suspended from the surface membrane and feed below the surface more easily and presumably more efficiently than the anophelines. Mechanically, however, these tube-bearing larvae can do nothing that the anopheline larvae can't do. Both swim and dive well, each can feed both at the surface or below. Are there other differences, perhaps physiological, perhaps related to stratification of food organisms, linked or correlated with the tube that have led to the development of this group? Regarding these points, there is a little evidence that culicine larvae can live in water with a lower oxygen tension than can those of anophelines. On the question of food stratification, limnological studies have shown that microorganisms occur at definite different depths during various parts of the diurnal cycle. The tube of the culicines and perhaps also their feeding times, may be correlated with the changing levels of microorganisms. One thing seems certain, that a structure of this sort would not have evolved unless it endowed its possessor with definite advantages in the struggle for existence.

A family tree of the group, Fig. 1(B), emphasizes some interesting points—(1) the antiquity of the anophelines, (2) the persistence of some early lines of the culicines, especially *Orthopodomyia,* and (3) the tremendous burst of development of diverse culicine lines at the apex of the tree. There is a very peculiar circumstance about this burst. It coincides with the development in the larva of a comb and some sort of pecten, many of them becoming highly developed in various species (Fig. 4). This poses a real question: What is the function of these structures? I have found no answer yet, but the evolutionary evidence is such that there seems no doubt but that the comb and pecten are highly advantageous to the larva.

One part of this burst of genera illustrates some of the restrictive limitations of specialization. The group of sabethine genera, represented in Fig. 1(B) by the series from *Wyeomyia* to *Topomyia,* lost the anal brush early in its history, probably as an extreme adaptation to living in container-type habitats. The group has evolved into a large fauna of genera and species, but has remained restricted to container habitats and has never reinvaded the open water habitats from which its earliest ancestor came.

We find some real paradoxes with regard to certain genera. Here are two instances. Both *Culiseta* and *Culex* ap-

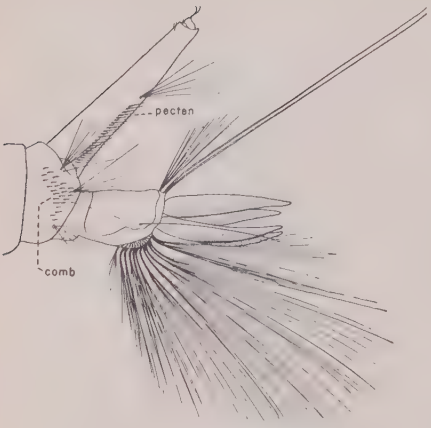

FIG. 4. Apex of abdomen of larval *Aedes fitchii* F. & Y., to show comb and pecten.

parently started out as temperate climate groups. Why did *Culiseta* develop primarily as a northern group while *Culex* developed almost entirely as a southern group and became a dominant tropicopolitan genus? An analysis of distributional data indicates that both *Uranotaenia* and *Aedes* started out as subtropical genera. Why did *Uranotaenia* stand still in an evolutionary sense while *Aedes* gave rise to the largest and most successful group of subarctic mosquitoes. It is possible that the desiccation resistant eggs developed by *Aedes* were the forerunner of cold resistant eggs, since desiccation and cold resistance are linked in other groups. It would be interesting to have some experimental evidence about the linkage in the subarctic mosquitoes.

The great burst of mosquitoes has the same evolutionary characteristics as the burst of mammals, and it seems reasonable to suppose that the two groups might have evolved together. The mosquito burst apparently started at least 120 million years ago, but (chiefly on negative evidence) the mammal burst is usually dated some 30 or 40 million years later. There is suggested here a possibility that prevailing ideas on mammal evolution may be incorrect on the time factor. *Plasmodium,* the malarial organism, is thought by some recent workers to have started out as solely a mosquito parasite and to have added its warm-blooded vertebrate hosts as a later development, their ideas based to some extent on the hypothesis that mosquitoes evolved before mammals. If, however, the mosquito and mammal groups arose together, perhaps the sequence of events regarding these parasites is quite different.

As you can well see, our results so far on the "What" of mosquito evolution have led chiefly to the formulation of questions as to the "How" and "Why" of these processes. It indicates our tremendous lack of fundamental information on the daily living processes of this group.

Perhaps some of the biological and physiological information that will explain the evolution of mosquitoes will also aid in devising means for their control.

THE ENTOMOLOGICAL SOCIETY OF AMERICA and THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS: The annual meeting of the Entomological Society of America and the American Association of Economic Entomologists will be held in Cincinnati at the Netherland Plaza Hotel on December 10, 11, 12 and 13, 1951.

THE EASTERN BRANCH of the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS will meet at the Hotel New Yorker in New York City on November 15 and 16.

THE ROLE OF INSECT CONTROL IN ARMY OPERATIONS

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Washington 25, D. C.[1]

In the presence of an expanding defense establishment one of the most pressing questions facing eligible young entomologists is the part they may expect to play in the event they enter army service. Fortunately, the niche into which entomologists fit has been fairly well defined through experience gained in their widespread utilization during World War II. The entomologist is a member of a team, a preventive medicine team, a team that is charged with the responsibility of protecting the health of troops wherever they may be, under all conditions of climate and environmental sanitation—or the lack of it. Team membership must, of course, vary with the problems encountered in different areas but in general may be thought of as being composed of enlisted preventive medicine technicians, and commissioned officer entomologists, sanitary engineers, parasitologists and medical doctors.

First, a word about the peculiar mission of these teams, peculiar in the sense that the mission differs quite markedly from that of similar teams in civilian life. The Army preventive medicine team has as its objective the prevention of all diseases which result in man-days lost from duty. And the military team cannot approach the problem slowly, relying upon the most efficacious method to achieve the desired objective over a period of time. Rather, the military team must do everything possible to prevent even the first case of a disease, since the occurrence of even one case means that in a sense the team has not performed its mission. Of course, faced with a multiplicity of disease entities, varying widely in their preventability, from smallpox which is relatively easy to prevent, to upper respiratory infections which are relatively difficult to prevent, the theoretical mission of the preventive medicine team is impossible of accomplishment with our present knowledge in the field of preventive medicine. The nearer the team can approach to the prevention of all diseases, the more nearly the team has achieved its objective.

Within the large group of so-called preventable diseases is a relatively large segment of what are broadly, and somewhat inaccurately, termed insect-borne diseases; inaccurate, because such diseases as scrub typhus, transmitted to man by a mite, are included. It is with the prevention of these diseases that the entomologist in the army is most closely associated, but the entomologist should never forget that he is a member of a team, a team whose mission is the prevention of all diseases, a team whose mission may require that he assist in the prevention of non-insect borne diseases. It is not intended that the entomologist be a "jack-of-all-trades and a master of none" but, to paraphrase, that he be a "jack-of-all-trades and a master of one."

Another fact which all too often is overlooked is that the principal problem facing the preventive medicine team today is the efficient implementation of control projects. Given adequate amounts of vaccines, prophylactic drugs, insecticides, pest control equipment, technical personnel and labor, coupled with command support, there is not one insect-borne disease of military importance which cannot be adequately controlled in the field. Granted, some insect-borne diseases are easier to control than are others, and that some control methods are very costly in

[1] Presented at the meetings by Lt. Daniel Reynolds, MSC, 2nd Army Area Medical Lab., 2121 ASU, Ft. George G. Meade, Md.

terms of time, money, and equipment. But the fact remains that the diseases can be prevented and that the principal mission of the entomologist on the preventive medicine team is to determine which of many control methods will be the most efficient. He facilitates and supervises the execution of these methods in the field, and develops more efficacious methods where possible, bearing in mind always that the sole reason for his existence as an entomologist in the Army is for the support of the infantry soldier, either directly, by preventing him from becoming infected, or indirectly by preventing other infantry supporting soldiers from becoming infected.

It will be seen, therefore, that an entomologist in the army must have the ability to appreciate his position on the preventive medicine team, the ability to establish good working relationships between himself, his subordinates and his superiors and the general entomological background required for the practice of his specialty. If one or more of these attributes are lacking the entomologist is more hindrance than help to the performance of the mission of the preventive medicine team and in turn, the performance of the mission of the Army Medical Service.

Another salient feature that becomes evident from the above discussion is that the requirements of a major mobilization for entomologists at the PhD degree level are going to be small, at the Master's degree level, somewhat larger; the remainder of the requirement being met by entomologists at the Bachelor's level. Although exact estimates are classified and cannot be released to the general public the percentage figures can be given, and will probably approach the following:

PhD	Degree	10%
MS	"	15–25%
BS	"	65–75%

This does not mean that we may have a higher ratio of PhD entomologists on duty, since it would obviously be better for both the army and the individual to have the PhD working in a job requiring only a BS degree than to have the PhD carrying a rifle in an infantry company. This, gentlemen, at the PhD and Master's level, may be the choice you will be called upon to make: to utilize your broad training in a position calling for a minimum of entomological background, or to enlist or volunteer as an officer in one of the other technical services or in the combat arms, where your broad training would not be utilized at all. It should be pointed out, however, that whether or not you are faced with this decision will be determined either by your own voluntary actions or by policies established by non-defense agencies responsible for the utilization of scientific man-power.

Next, to look for a moment at the actual composition of the preventive medicine team—unfortunately, no two areas in the world are exactly alike, and the composition of the team must be adjusted to meet the problems encountered. For this reason, it has been found necessary to form what might be called sub-teams or building blocks of which the overall teams are made up. These subteams are as follows:

The Preventive Medicine Control Detachment, T/O & E 8–500 LA [2]

The Preventive Medicine Survey Detachment, T/O & E 8–500 LB

and are supplemented and supervised by:

Preventive Medicine Officers	MOS 3005 [3]
Entomologists	MOS 3315
Sanitary Engineers	MOS 7960

The detachments themselves are made up as follows:

a. *Preventive Medicine Control Detachment.*

1 Captain (Entomologist or Sanitary Engineer)

10 enlisted men, of which 6 are preventive medicine technicians and 4 are non-technical enlisted men

[2] Table of Organization and Equipment.
[3] Military occupation specialty.

b. *Preventive Medicine Survey Detachment.*

2 Captains (1 Entomologist and 1 Entomologist, Parasitologist, or Sanitary Engineer)

11 enlisted men, of which 8 are preventive medicine technicians and 3 are non-technical enlisted men.

These building blocks are usually allocated to an area on the basis of 1 Survey Detachment to 3 Control Detachments, and are best thought of as being mobile groups of labor crew foreman and field inspectors (enlisted men) and technical supervisors (commissioned officers). The units obtain labor from many sources, among them being natives, military prisoners, prisoners-of-war, or when none of these are available, by means of levies on other troop units.

Those of you who are familiar with the Malaria Survey and Control Detachments of World War II, will recognize the origin of the Preventive Medicine Detachments. As many of you may know, however, small detachments of this type are unsatisfactory from many points of view. They are thrown wholly on the none too tender mercies of the major command to which they are attached and in many instances do not have officers representing them on the Staffs of Corps, Armies, and Base Sections, who will fight their continuing battles of supply and motor vehicle priorities, motor vehicle repair, messing and housing.

Because of the inherent difficulties in the administration and supply of small detachments, steps were initiated to reorganize these units following the close of World War II culminating in the issuance on 12 May 1950 of T/O & E 8–117, Preventive Medicine Company. This company in essence is composed of the technical personnel of 3 Control Detachments, 1 Survey Detachment and a hypothetical Hygiene and Sanitation Detachment, and is allocated to areas requiring the support of one or more Survey Detachments plus 3 or more Control Detachments. A reduced strength column in which one Control Section is eliminated adds to the flexibility of the organization.

The full strength Company includes:

6 officers (2 Captains and 4 Lieutenants) which may be any combination of entomologists and sanitary engineers, as required

1 warrant officer—administrative

59 enlisted men, of which 42 are preventive medicine technicians and 17 are non-technical enlisted men.

This unit is wholly self-sufficient with respect to mess, motor vehicle repair and internal administration by non-technical personnel and has proved to be much more satisfactory than the separate detachments in these respects. Although this company solves many of the problems inherent in the utilization of small detachments, one major problem still remains—that of interested staff representation. This problem is being partially solved by the establishment of Battalion Headquarters under T/O & E 8–26, Medical Battalion Headquarters (Sep). This Headquarters will probably contain one Lieutenant Colonel (MOS 3005, Preventive Medicine Officer), 2 Majors (one Sanitary Engineer and one Entomologist) plus two administrative officers and 25 non-technical enlisted men.

In addition to vacancies in Table of Organization Units for entomologists, vacancies also occur in the Staffs of Base Section, Corps, Army and Theater commanders, where the entomologist is primarily concerned with the technical supervision and administration of approved projects.

A limited number of vacancies also exist in Army Area and Field Laboratories, in Army Medical Service technical schools and in Research and Development activities.

In conclusion it may be stated that the Army Medical Service has developed an extensive career field for the utilization of

entomologists covering the rank span of 2nd Lieutenant to Colonel, a career field in which the entomologist combines entomological and military skills in support of the assigned mission of the Army Medical Service—which is ". . . the conservation of man power—the preservation of the strength of the military forces."

MALARIA CONTROL PROGRAM OF THE TENNESSEE VALLEY AUTHORITY

F. E. GARTRELL
Chief, Malaria Control Branch, Division of Health and Safety, TVA

The malaria problem confronted TVA as soon as it began planning for development of the Tennessee River. Prior reservoir impoundments in the southeastern United States proved, in virtually every instance, to be ideal breeding grounds for anopheline mosquitoes and resulted in serious epidemics of malaria. This was true of projects constructed in Alabama on the Cahaba River in 1910 and on the Coosa River in 1914. It was also true of reservoirs constructed on the Tennessee River itself at Hales Bar in 1912, at Lake Wilson in 1924, and at Widows Bar in 1926. These unfortunate experiences led to extensive investigations by the United States Public Health Service which are considered to be the starting point of present day knowledge of malaria control on impounded waters. In 1923, Alabama adopted regulations, which have since served as a model for many other states, requiring that any individual or private or municipal corporation apply malaria control measures in impounding water or raising the level of an existing pond.

In the early 1930's, despite advances in knowledge concerning the control of malaria, the disease still constituted one of the most important public health problems of the southeastern United States. For example, in 1934, a malaria survey was made of the proposed basin of Wheeler Reservoir and the area within mosquito flight range (one mile) of its margin. A total of 5,023 blood specimens were collected; of these, 35 per cent were found positive, the maximum rate reaching 65 per cent in 2 counties. In a survey by the Alabama State Health Department a year earlier around Lake Wilson, 23 per cent of the individuals tested were found positive for malaria. It goes without saying that such high malaria incidence results in economic losses which can retard seriously the development of a region.

TVA's plans for creation of a chain of artificial lakes, which presently cover more than 600,000 acres with over 10,000 miles of shoreline, in a region where malaria already existed to a serious degree offered an unprecedented control problem. Moreover, this problem was intensified by the multipurpose character of the system which was to be operated for flood control, navigation, and the generation of power, and would require flexibility in water level changes to meet the needs of all three purposes. No similar development had previously occurred in this country from which to draw experience.

To cope with this problem, TVA assembled a staff with special training in medical malariology, biology, and engineering. They were associated within a single division and given the responsibility of developing a malaria control program for the entire river development. Special consultants were called in from the United States Public Health Service, the Department of Agriculture, the Rockefeller Foundation, universities and other

agencies. In addition, the TVA staff has worked closely with the state and county health organizations of the Valley.

From the beginning, emphasis of the malaria control program has been upon measures directed at control of the vector, *Anopheles quadrimaculatus*. Every effort has been made to achieve the greatest possible integration between research into new methods of control and application of such research in actual control work on and along the reservoirs. New control ideas, whether originating with the TVA research staff, with the TVA field forces, or outside the agency, are first tested in the laboratory and subsequently tried on a small scale in the field; if they still appear promising, larger-scale field application is carried out before the method is incorporated into the program.

Program Elements

Reservoir Preparation

When TVA began its control work, the clearing of reservoirs and construction of marginal drainage ditches were recognized as standard practice. However, impoundment of the vast acreage contained in the shallow portions of the TVA main river reservoirs, in poorly drained areas with luxuriant plant growth, resulted in an unprecedented anopheline mosquito production potential. TVA accordingly undertook studies for the purpose of developing improved methods for conditioning these marginal portions of the reservoirs. The new developments adopted as a result of these studies include the low cutting of stumps, which results in less resprouting after impounding; the poisoning of willow stumps, which had been found to produce the most abundant and objectionable marginal growth; the final removal of marginal regrowth in the autumn prior to the initial impoundage; and special clearing practices for margins of reservoirs. In one reservoir, Kentucky, an extensive program of permanent shoreline improvement to eliminate potential mosquito breeding areas by deepening-and-filling and diking-and-dewatering was carried out prior to impoundage. The adoption of these improved procedures resulted in a much more effective reservoir preparation and decreased the cost of subsequent maintenance operations.

Water Level Management

By 1933, the year in which TVA was organized, it had already been established that water level fluctuation could be used as an effective method of mosquito control. Reliance at that time was placed chiefly upon a spring surcharge followed by cyclical fluctuation, or where this was not possible, upon seasonal water level recession. TVA undertook a series of initial experiments on a small pond to determine more effective methods of using water level management. Information obtained from these experiments was then applied on Lake Wilson as a proving ground, with periodic biological and engineering investigation of results, and over a period of years improved schedules have been developed. Water level regulation for malaria control has been successfully fitted into the operating schedules required for flood control, navigation and power.

Water level management is the most effective single malaria control measure. The schedule on the main river reservoirs includes: (1) raising the water above normal maximum summer level in late winter or early spring and then returning it to that elevation in order to strand the winter's accumulation of drift and flotage; (2) maintaining the water at the normal maximum summer elevation during the spring growth period to retard marginal vegetation; (3) cyclical fluctuation of the water levels about 1 foot at weekly intervals during the late spring and early summer in order to kill mosquito larvae by stranding them on shore or exposing them to natural enemies such as top minnows; and (4) combining a seasonal recession of about 0.1 foot to 0.2 foot per week with cyclical fluctuation in order to insure effective control of mosquito larvae during the peak of the mosquito breed-

ing season in the summer and early fall. On the storage reservoirs effective mosquito control is usually obtained through the use of wide seasonal recession.

Permanent Shoreline Improvements

Shoreline alterations to eliminate permanently the most serious mosquito breeding areas in the lower main stream reservoirs are being made. These shoreline improvements consist mainly of diking-and-dewatering and deepening-and-filling. The latter method consists of deepening the lower half of shallow mosquito breeding areas and placing the excavated earth on the upper portion of the area. Diking-and-dewatering consists of building dikes to separate large shallow areas from the lakes and installing pumps to remove water which accumulates behind the dikes.

Approximately 9,100 acres, 50 per cent of the total 18,200 acres proposed for permanent shoreline improvement measures in TVA reservoirs, have been completed.

Of the 9,100 acres completed, 4,960 acres are included in ten diking-and-dewatering projects, eight in Kentucky Reservoir and two in Wheeler Reservoir. Completion of the permanent shoreline improvement program was originally scheduled for fiscal year 1953, but work is being curtailed to accommodate more acute defense needs.

Insecticiding

In 1933, two larvicides were in general use for the control of malaria mosquitoes. One was a mixture of kerosene and black oil applied mainly by knapsack and occasionally by boat pumping units; the other was paris green, which was diluted with an inert substance and applied to the surface of the water by hand dusters. These procedures, on limited areas and under appropriate supervision, produced moderately effective results. The size of the projected TVA development, and particularly its tens of thousands of acres of shallow water not readily accessible from either shore or boat, required something better.

As initial steps in developing more effective insecticidal techniques, TVA adapted a water-oil pumping unit for applying the oil-kerosene mixture to the types of shoreline which could be reached by shallow-draft boats; an orchard-type duster for applying paris green from marine equipment; and facilities for the mixing and storage of larvicidal materials at convenient points about the reservoirs. Next, TVA investigated the possibilities of applying paris green from airplanes. The practicability of this method of application had been demonstrated on a limited scale in the 1920's by the U. S. Department of Agriculture. The method was never generally adopted, however, and equipment was lacking with which to put it into effect. TVA developed modified dust hoppers, together with methods for mixing paris green and its diluent, and for sacking and storage. When Wheeler Reservoir was impounded in 1937, it was possible, as a result of the collaboration of TVA technicians with personnel of other governmental agencies and commercial crop dusting organizations, to demonstrate successfully the superiority of airplane application of paris green from the standpoint of both economy and effectiveness.

During World War II, as DDT and other new and more effective insecticides appeared, TVA immediately tested them to determine their effectiveness in the control of anopheline mosquitoes, and to develop satisfactory formulations and equipment for their distribution by airplane, boat, and hand. The first airplane application of DDT for mosquito control was carried out by TVA in cooperation with the U. S. Department of Agriculture in 1943. Later, as the result of a cooperative project undertaken by TVA, the U. S. Department of Agriculture, and research units of universities working under grants from the Office of Scientific Research and Development, a new type of DDT solvent was used and an exhaust generator was developed for the production of an aerosol or mist-type spray

which could be readily adapted to small airplanes. Because of the small quantity of DDT thermal aerosol (0.1 lb. DDT per acre) necessary for satisfactory control and its more effective penetration of vegetation, this development increased tremendously the effectiveness and economy of airplane distribution. This was followed by development of spray equipment which reduced the normal application rate required to .05 lb. of DDT per acre. DDT applied by airplane as a spray has completely replaced all other methods of larviciding. Recent investigations have demonstrated that helicopters can be used satisfactorily for application of larvicides under conditions prevailing on TVA lakes, but they do not appear to be superior to the fixed-wing aircraft presently used. TVA uses helicopters for transmission line patrol and a demonstration is scheduled for the summer of 1951 on joint use of a helicopter for both transmission line patrol and malaria control, which if practical would result in economies to both programs, because of better utilization of equipment and pilots than is the case with present arrangements.

During the early years of TVA impoundages, there were certain limited areas in which adequate mosquito control was impracticable with any methods then available. It was therefore decided to employ the mosquito-proofing of houses within these areas as a temporary emergency measure until more permanent measures could be applied. Following the wartime demonstration of the effectiveness of wall sprays of DDT in eliminating flies and mosquitoes, spraying methods were developed which field tests demonstrated to be practicable in the TVA area. Thereafter, with the approval of appropriate state health departments, the residual spraying of all dwellings and other structures of premises with this material was substituted for mosquito-proofing maintenance. Beginning with the 1951 season, routine use of premises spraying in these areas is to be discontinued, and the areas are to be included in the regular anti-larval program. This change was made possible by the cumulative beneficial effects of water level management in controlling marginal vegetation, progress on permanent shoreline improvement, and increased effectiveness of larviciding techniques. Residual spraying of premises may be utilized whenever emergency situations indicate the need for additional malaria control measures.

Shoreline Maintenance

TVA's early experience with larvicides emphasized the costly and repetitive nature of that type of control. In its search for possible alternatives, TVA investigated the possibility of controlling vegetation along the margin of the reservoirs. It was soon found that annual shoreline conditioning not only increased the effectiveness of larvicides but limited the need for their application. At first, water-tolerant woody plants such as willow and buttonball and stiff-stemmed marginal weeds were cut by hand, but operations were gradually mechanized and area burning was developed for certain situations. Water level schedules have been effective in limiting the zone of marginal growth invasion to 1½ to 2 feet below normal pool elevation. Growth removal operations have been further limited by establishing the "shoreline maintenance line" approximately ½′ below normal pool elevation, since experience has demonstrated that this is a practical procedure in light of water level schedules employed on the five reservoirs where growth removal operations are required. Drift removal is a minor operation and is limited to situations where it has accumulated to the extent that it constitutes a favorable mosquito breeding area. Recurrent cutting, first by hand and later mechanically, together with some use of conventional herbicides, proved moderately successful in the control of aquatic plants. With the advent of 2, 4-D, more effective means of controlling many such plants became possible. Formulations of 2, 4-D have been found to be effective in the control of black willow, trumpet vine, lotus, parrot's

feather, water primrose, water willow weed, cocklebur, and giant ragweed. Effective treatment has not yet been developed for alligator grass, buttonball, and cattail.

Drainage Maintenance

Maintenance of existing marginal drainage systems is required to assure maximum effectiveness of water level fluctuation for mosquito control. Dynamite is used extensively, but hand operations are also employed. Herbicides are used where willows and other plants tend to clog or retard the flow in the ditches.

SUMMARY OF MALARIA CONTROL MEASURES

With the exception of one area in Kentucky Reservoir where malaria control easements prohibit nighttime occupancy of the one-mile zone of the reservoir during the period May 1 to October 1, the TVA malaria control program is directed toward control of the vector, *Anopheles quadrimaculatus,* on TVA reservoirs. Water level management is the foundation of the control program, and malaria control needs have been integrated into schedules which meet the primary requirements of the projects for navigation, flood control, and power purposes. Water level schedules have been effective both by limiting marginal growth, which indirectly affects mosquito production, and by stranding mosquito larvae or exposing them in open water to wave action and natural predators. Of the twenty-four reservoirs in the TVA system, water level management alone provides satisfactory mosquito control on sixteen reservoirs; on two reservoirs only occasional and limited larvicidal operations are required; and routine seasonal larvicidal operations and other measures are scheduled on only six reservoirs. Larvicidal operations consist of application of DDT as spray by airplane at a rate of approximately 0.05 pounds of DDT per acre, with entire operation being handled by four fixed-wing airplanes. Shoreline maintenance operations include marginal growth removal, aquatic growth control, drainage maintenance and drift removal, with work being limited to those areas of highest anopheline production potential. Diking-and-dewatering and deepening-and-filling have been employed to eliminate some major mosquito breeding areas in the margins of TVA lakes, and a program is now in progress which is scheduled ultimately to improve the shoreline in all of the principal malaria mosquito breeding areas to the end that with normal water level management schedules only a minimum of supplementary control measures will be required. The program provides for use of DDT premises spraying for emergency situations where, for any reason, antilarval measures fail to provide satisfactory mosquito control.

Program Appraisal

In order to appraise the effectiveness of its control program, the Authority in cooperation with state health departments makes routine inspections of designated mosquito collecting stations during the mosquito season and carries out malaria surveys in areas adjacent to the reservoirs. The effectiveness of the mosquito control program is indicated by results of inspections during the 1950 season when 8,595 inspections were made and the average count per inspection was 1.7 female *Anopheles quadrimaculatus.* The results of the malaria blood film surveys likewise attest to the effectiveness of the control program. The results of the past two seasons showed all blood films to be negative, whereas in 1934 similar surveys showed 28 per cent were positive. Thus, despite the tremendous increase in malaria transmission potential resulting from the creation of the TVA chain of lakes, malaria control has been achieved to the extent that the reduction in malaria around TVA reservoirs has paralleled the general decline of malaria in the Southeastern United States.

SOME MOSQUITO-LIKE NUISANCE PESTS AND THEIR ECONOMIC SIGNIFICANCE

BERTRAM I. GERRY
Massachusetts Reclamation Board

For the past two decades, numerous minor midge outbreaks have been reported to the Massachusetts State health authorities, but in only two instances have conditions warranted a comprehensive investigation as the result of these complaints.

1. *Musquashcut Pond.* The first instance, in 1937, involved Musquashcut Pond, in the town of Scituate. (See Fig. 1.) This pond has a water area of approximately 74 acres, with a maximum depth of 4 feet, and an average depth of 2.1 feet. The bottom consists, primarily, of fine sand and some scattered mud deposits. The water is brackish with a chloride content varying from 2,700 to 4,500 parts per million. Although there is no direct sewage discharge into the pond, some pollution occurs as the result of seepage from nearby cesspools, and other sewage works. In the shallow areas, surface temperatures reach 92° F., and bottom temperatures 83° F., during the month of August. The dissolved oxygen content, which varies from 5.4 to 14.0 ppm, is adequate to support fish life.

Between early April and the second week in July of 1937, Musquashcut Pond was stocked with an assortment of fish, which included: smelts, eels, alewives, sticklebacks, killifish, shiners, and white perch. As a result, no midge nuisance occurred during that season. In the meantime, a number of experiments were initiated to determine whether an insecticide might be used effectively for the elimination of *Tendipes decorus* larvae. Data from these experiments showed that pyrethrum flowers, applied at the rate of 1 part flowers to 1,500 parts water, would kill 100 per cent of the midge larvae in 18 hours. However, this type of insecticidal control was not developed beyond the experimental stage because of the excessive cost. As an alternative, it was recommended: (1) that the pond be restocked with fish, (2) that a screen be installed at the outlet to prevent loss of the fish, and (3) that a plank dam be built at the outlet to increase the depth of the

Fig. 1. Musquashcut Pond adjacent to Summer Colony.

pond. Observations, made over a period of ten years (1937 to 1946), indicated that conditions were not improved sufficiently to favor the establishment of a permanent fish population. This conclusion was supported by the recurrence of the midge nuisance. The unusually high temperature of the water, and the generation of hydrogen sulphide in the bottom mud, seem to function as serious limiting factors in respect to fish life, the latter showing, also, a detrimental effect upon midge development. The fact that most fish will succumb to hydrogen sulphide, when present in quantities greater than 1 ppm, has been well established. Although information relative to the tolerance of blood worms to this gas is unavailable, it was noted that these larvae were scarce in the gas-generating mud, but thrived in considerable numbers, where the bottom mud was well diluted with sand. In 1947, a DDT residual spray was applied to all vegetation existing on the land immediately adjacent to the pond. It was anticipated that the midge adults would acquire a lethal dose of DDT while resting on the treated vegetation between flights. This method of attack provided reasonable relief from the midge nuisance, and has been repeated annually, since 1947, at a nominal cost.

2. *Merrimack River.* A more recent midge outbreak occurred along the Merrimack River during 1949 and 1950. A wide divergence exists between the general conditions encountered at Musquashcut Pond, described above, and those found in the Merrimack River area. The Merrimack River is a heavily polluted active stream, with an average June flow of 4,214 million gallons per day over the past 68 years; the chloride content, in the area under observation, ranges from 113 ppm at the narrows, known as the Lion's Mouth (see Fig. 2), to 14 ppm at the upstream end of the ponded area, known as the Middle Ground (see map); the water temperature, taken over a six-year period, from June to November of each year, averaged 68° F. at the sampling station located just below the narrows, and 67° F. at the second sampling station located approximately 10 miles upstream from the first; and the dissolved oxygen content ranged between 1.6 and 3.2 ppm during August—well below that required by fish. The surface of the flats, which extend along both shores of the ponded section of the river, referred to as the Middle Ground, is covered with a layer of blackish organic sludge from 2 to 3 inches in depth. In some areas, where the strength of the current is reduced, this

FIG. 2. Merrimack River showing Ponded Area.

sludge extends, in irregular patches, well out into the channel. While the muddy areas on the bottom of Musquashcut Pond supported few if any midge larvae, the sludge masses, scattered over the bed of the Merrimack River, harbor larvae of *Glyptotendipes lobiferus* in great numbers. This river sludge functions as a protective medium into which the larvae burrow; it furnishes material for case making, and serves, also, as a nutrient culture for the rapidly developing blood worms.

Fellton (1940) demonstrated the importance of this type of medium for rapid and vigorous development of *Glyptotendipes lobiferus*. Newly hatched larvae of this species were released in a laboratory culture consisting of washed sand and tap water, to which was added, occasionally, a drop of skim milk. Under the above conditions. *G. lobiferus* larvae required 5 months to develop to the pupal stage. In a second culture containing organic matter taken from the bottom of the heavily polluted lake, plus tap water, and skim milk applications duplicating those added to the first culture, the newly hatched *G. lobiferus* larvae developed to the adult stage in slightly less than two months.

On this basis, the Merrimack River presents conditions favorable for an abundant and rapid propagation of the *G. lobiferus* species. In addition, the heavy pollution (BOD of 10) reduces the dissolved oxygen content to a point where fish—the major predators of midges—cannot exist. Fellton (1941) carried on his experimental work on a brackish lake which showed no tidal activity. He applied orthodichlorobenzene just below the water surface at the rate of 22 gallons per acre. His treatment provided excellent control of midge breeding. However, on the Merrimack River, where a definite tidal action causes exposure of the sludge covered flats for several hours each day, a water emulsion containing .06 per cent pyrethrins was applied directly to the exposed sludge. As a result of this treatment, a high percentage of the blood worms came to the surface of the sludge within 2 minutes, and showed no evidence of life after approximately 5 minutes of contact with the toxic spray.

Economic Significance

Although H. K. Townes (1945) in his "Nearctic Species of Tendipedini" states that *Tendipes riparius* and *T. tentans* are the only blood worms which indicate pollution, a series of midge studies conducted along the Illinois River by Richardson (1915–1922) indicated that *T. plumosus* and *T. decorus* both favor heavily polluted waters; Weston and Turner (1917) found *T. decorus* abundant in the effluent stream at the Brockton sewage disposal system; and Fellton (1940) found *Glyptotendipes lobiferus* and *T. stigmaterus* breeding abundantly in a heavily polluted lake located on the Flushing Meadows in New York City. Furthermore, Richardson observed that in the Illinois River, where pollution increased noticeably between 1915 and 1920, *T. plumosus* and *T. decorus* increased 190 fold. In addition, Lindeman (1942) reported that *T. plumosus* and *T. decorus* were quite tolerant of anaerobic conditions. Our experience, and that of Fellton, indicate that *G. lobiferus* reacts to increased pollution in the same manner as *T. plumosus* and *T. decorus*. It is evident that as streams become more heavily polluted, and fish life disappears because of the reduction in the dissolved oxygen content, one may expect an increase in midge breeding.

At Scituate, the midge nuisance is economically important because the major industry of the town is summer recreation; the permanent population being 5,282 (1950 census), while the summer population approaches 25,000. The total valuation of the town is $14,789,294, about 60 per cent of which represents beach and summer homes. The cost of midge control at Musquashcut Pond averages $200 per year, or one thousanth of a mill for each $1.00 of taxable valuation. This small investment shows a fantastic dividend, when balanced against the estimated losses, which might accrue as the result of a continued midge nuisance within the summer colony.

On the Merrimack River, in the vicinity of Merrimacport, phenomenal swarms of *Glyptotendipes lobiferus* during the evening create distracting air vibrations which resembled those emanating from a mowing machine operated at high speed. During the day, these pests accumulated on, or in the immediate vicinity of residences located along the river. Their favorite resting places include screen doors, or window screens, from which position a small percentage of the adults succeed in invading the interior of the homes. In the evening, they are attracted, also, in considerable numbers, to the intensely illuminated refreshment stands located along an important travel route which parallels the river. The midges which emerge from the river flats seem to retain in their tissues some of the waste dyes which have been discharged into the stream by local industrial plants. They retain, also, some of the dried sludge on their appendages. When alighting upon washing, hung out of doors, they leave fine crow's-foot markings on the fabrics. If crushed on wallpaper or upholstery, they produce large unremovable stains. During the summer of 1950, this midge nuisance became sufficiently serious to warrant an investigation by State authorities. As a result of the investigation, funds were made available for a life history study, and also, for control studies of this pest so closely associated with river pollution.

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1952 CONVENTION

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

One of America's most interesting cities will be the meeting place of the 1952 convention of the American Mosquito Control Association, Inc. The meetings will be held in the Hotel Utah, Salt Lake City, on March 24 to 27, 1952.

All Mosquito Control Agencies are urged to include provisions in their budgets for attendance at this meeting, and make reservations early.

Members of the Utah Mosquito Abatement Association will serve as hosts, and are making special plans for the entertainment of guests, including a tour of the city and vicinity, covering interesting phases of the work of the local Mosquito Abatement Districts, and other points of interest such as Great Salt Lake, the largest open-pit copper mine in the world at Bingham, The State Capitol Building, "This Is the Place" Monument on the site of the entrance of the first pioneer group into the valley, the Temple grounds, and other historic points. Hospitality hour and a banquet will be held in the Hotel Utah.

The Ladies' committee will entertain visiting ladies with a tour of the city, including a special request organ recital in the famed Tabernacle, and a luncheon in the Lion House, the former home of Brigham Young, leader of the first settlers in the valley of the Great Salt Lake.

Every effort will be made by the Utah Association to make this convention a most enjoyable and informative meeting.

The program committee of the A.M.C.A. consists of the Regional Directors, with Dr. C. R. Twinn of Canada as chairman. Plans are being made for an outstanding program. If you have any suggestions, submit them at once to your Regional Director or to Dr. Twinn.

We will see you in Salt Lake City in 1952.

OPERATIONAL INVESTIGATIONS DEALING WITH MOSQUITOES IN CALIFORNIA [1]

G. EDWIN WASHBURN,[2] R. F. PETERS,[3] AND D. C. THURMAN, JR.[4]

INTRODUCTION

The Bureau of Vector Control and the mosquito abatement districts represented in the California Mosquito Control Association have for several years recognized the need for biological investigations of California mosquitoes aimed toward evaluating the efficiency of present control methods and developing effective new control methods. About two million dollars each year is expended for mosquito control in this state; thus, control measure refinements may result in extensive savings. The principal mosquito control problems of the state are related to irrigation. Problems of secondary importance are related to natural waters including salt marshes, rivers, lakes, and flood areas. Associated with irrigation mosquito problems, two principal agricultural practices contribute to the main sources of mosquitoes in California's great Central Valley: (1) the irrigation of permanent pasture and (2) the flooding of rice fields.

In view of this urgency, and since investigations of the biology of mosquitoes in rice fields and in irrigated pastures would develop information which could be related to most of the mosquito problems in other agricultural situations, these two problems were selected for initial consideration. A third problem of basic importance is that associated with the development of efficient toxicants, the study of toxicant failures, and the precision application of presently recognized toxicants.

While these problems have been recognized for a number of years, the first large-scale coordinated attack on the problems was developed on a cooperative basis between the Bureau of Vector Control and the California Mosquito Control Association. This was conceived at the 1950 California Mosquito Control Association Annual Conference by a resolution, and through the appointment of a committee designated as the Operational Investigations Committee. The California Mosquito Control Association has, through this Committee, taken positive action in developing and promoting an effective program of biological investigations of mosquitoes in California. Through cooperative agreements between the Bureau of Vector Control and several of the mosquito abatement districts, $25,000 was set aside to conduct these investigations in subvented mosquito abatement districts.

The Operational Investigations Committee [5] in April of 1950, after making an intensive study of the problem, forwarded to the Bureau of Vector Control its recommendations for the investigational program for fiscal year 1951, including nominations of essential local cooperating agencies. Following approval

[1] Contribution of the Bureau of Vector Control, California State Department of Public Health; California Mosquito Control Association; and Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Ga.

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[4] Senior Assistant Sanitarian, Public Health Service, Berkeley, California; now with U. S. STEM, U.S.P.H.S., Thailand.

[5] Membership of Operational Investigations Committee: G. Edwin Washburn, Turlock Mosquito Abatement District, Chairman; Gordon Smith, Kern Mosquito Abatement District; John Shanafelt, Orange County Mosquito Abatement District; Don Murray, Delta Mosquito Abatement District; E. C. Robinson, East Side Mosquito Abatement District; D. C. Thurman, Public Health Service, Bureau of Vector Control; Herbert Herms, Sutter-Yuba Mosquito Abatement District; Ted Aarons, Alameda Mosquito Abatement District.

by the Executive Committee of the California Mosquito Control Association and the Bureau of Vector Control, three units were established:

1. One unit was established with the Turlock Mosquito Abatement District at Turlock, California, as the administrative entity cooperating with this project.
2. A second unit was established with the Sutter-Yuba Mosquito Abatement District at Yuba City, California.
3. A third unit was established with the Kern Mosquito Abatement District at Bakersfield, California.

All mosquito abatement districts interested in the results of this work have cooperated by furnishing manpower and equipment whenever it was possible for them to do so.

Considerable progress has been made during the brief period of the existence of these three investigational units. The toxicant investigations project has been somewhat delayed, however, due to personnel problems and other reasons.

In discussing the results of these investigations, only the results of the first two will be given; while for toxicant investigations, the plans for the next season will be given.

THE PROGRAM

Investigations of the Biology of Irrigated Pasture Mosquitoes (Conducted at Turlock)

This project has been a cooperative study between the U. S. Public Health Service, the Bureau of Vector Control, and the Turlock Mosquito Abatement District as sponsored by the California Mosquito Control Association.

During the 1950 mosquito season, investigations have been divided into several phases. They have included:

1. A study of the cycles of mosquitoes during the successive irrigations in a permanent irrigated pasture.
2. The study of the feeding habits and activities of adult mosquitoes in a single pasture, and the relationship that these activities may have to the transmission of disease.
3. Flight range and dispersal studies of *Aedes* mosquitoes from irrigated pastures.

In order to facilitate these studies, a field station was established at Turlock, and equipped with materials and personnel. The study area selected was an irrigated pasture located about 8 miles west of Turlock. Temperature and humidity records were kept, using a hygrothermograph. In the course of each of the 18 irrigations in this pasture, a mosquito cycle was begun and completed. During each of these mosquito cycles, records were kept of the hatching and distribution of mosquitoes over the pasture, of the emergence patterns of adults, and of adult density indices.

To accomplish the second phase of the study, females of the species *Aedes nigromaculis* (Ludlow) were taken from the pasture and records made as to whether or not they had fed or were gravid. The engorged females were dissected, and blood from their stomachs was smeared on filter paper. These blood specimens were then stored, and will be tested at a later date to determine which animal hosts provided the blood meal. Diurnal and nocturnal activities of adult mosquitoes were observed, and light trap collections were made both within the pasture and near by.

Two methods were used in the study of flight range. The first called for tagging the mosquitoes with rhodamine-B fluorescent dye, and the second, with a radioisotope P-32. The rhodamine was applied to the mosquitoes in their natural habitat, using an aqueous solution of about one pound to five gallons of water, applied with an insecticide fog generator but omitting the use of the heat mechanism. The radiophosphorus was placed in two large galvanized iron tanks holding about 80 gallons of water in which the mosquito larvae were concentrated. Fourth stage *Anopheles nigromaculis* were introduced into the tanks and there

ingested the isotope. On emergence they contained enough radiophosphorus for easy detection with a Geiger counter (Tracerlab Su-3A Laboratory Monitor).

Investigations of Biology of Rice Field Mosquitoes (Headquarters at Yuba City)

This project has been a cooperative project of the Bureau of Vector Control, and the Sutter-Yuba Mosquito Abatement District, sponsored by the California Mosquito Control Association.

The objective of this study was to increase the knowledge of the natural history of rice field mosquitoes, in view of the need for improving control measures. For the spring of 1950 the principal activities included:

1. A study within a 25-square-mile area, where intensive springtime larvicidal measures had been applied to all infested aquatic sources. The purpose was to determine whether or not this spring control would significantly decrease the numbers of *Anopheles* and *Culex* mosquitoes which occur in the rice fields after they are flooded in May.
2. Studies were conducted to determine the relative mosquito productivity of various aquatic sources, using dipping records as a means of comparison.
3. Inspections of adult resting stations were used to study fluctuations in adult populations.

The study area of 25 square miles is located in southern Sutter County and includes 2,320 acres of rice and 1,960 acres of irrigated pasture. The remaining 11,720 acres are largely fallow fields which are not subject to irrigation. Extensive larviciding was done during the months of March and April in an attempt to control all sources of mosquitoes in this 25-square-mile area. A central, mile-square section was used for intensive observations in the hope that records in this section would indicate the degree of mosquito reduction obtained and would not be influenced too greatly by those areas outside the 25-square-mile, intensively controlled area. Following the flooding of the rice fields in April and May, dipping records were kept on the occurrence of mosquito larvae. Adult resting station and light trap collections were made to determine adult density indices.

To discover additional facts concerning the biology of the principal rice field mosquitoes, *Anopheles freeborni* Aitken and *Culex tarsalis* Coquillett, living specimens were collected and observed under laboratory conditions. The numbers of eggs laid by females of both species were recorded for these conditions. Dissections for ovarian and fat body development of female *Anopheles* in relation to seasonal changes are also under way. Field observations were made of the length of time required for adults to emerge after flooding certain rice field sections. Dipping records indicate that samples taken in one part of the rice field may not represent conditions over the remainder of the field. Therefore, it is exceedingly difficult to establish reliable indices to larval mosquito densities in rice fields.

In the resting station counts for the 1950 season, *Anopheles freeborni* females reached a peak on September 8, 1950.

Observations have been made concerning the swarming and mating habits of *Anopheles freeborni*. It is hoped that this study will demonstrate differences in seasonal activities of both *A. freeborni* and *Culex tarsalis*.

Presentation of Results

It has been the opinion of the Bureau of Vector Control and the Operational Investigations Committee that three phases exist in the conduct of these studies: first, a study of the natural history of mosquitoes and the effect of toxicants on mosquitoes; second, the organization of results of these studies for presentation in the form of reports to mosquito abatement districts and to the Bureau of Vector Control; and third, interpretation of the information given in these studies so that it can be used effectively in guiding control operations.

From the inception of these projects, every attempt has been made to keep both investigators and mosquito abatement district personnel abreast of all developments related to the organization and operation of the projects, as well as cognizant of the results of the investigations. Thus, knowledge gained can be utilized in the control program of the districts at the earliest possible moment. This has necessitated frequent meetings of the Operational Investigations Committee in which the progress of the studies has been discussed in detail. Coordination of all effort through the Biological Section of the Bureau of Vector Control has worked effectively in directing the purpose of the investigation program. At regional meetings of the Mosquito Control Forums in the San Joaquin Valley, the Sacramento Valley, the San Francisco Bay Region, and in southern California, mosquito control workers have been apprised of the results of each project. Thus, it is the intention of the California Mosquito Control Association and the Bureau of Vector Control to make the most of every dollar spent in this work through rapid integration of investigative results and operational programs.

PLANNING FOR THE FUTURE

In planning future mosquito investigations, there are four phases under consideration for the 1951 mosquito season. These will include:

1. Continuation of flight dispersal studies of irrigated pasture mosquitoes.
2. Investigations directed toward learning more about the eggs of *Aedes, Culex,* and *Anopheles* and the potentialities of methods for destroying mosquito eggs.
3. A continuation of the biological studies of rice field mosquitoes.
4. Expansion and intensification of the study of toxicants for mosquito control.

The first three programs will proceed along much the same lines as during the 1950 season. It is anticipated, however, that in a study of toxicants, we may be able to increase our activities in several ways. The first way is through cooperation with the Corvallis, Oregon, U. S. Department of Agriculture Laboratory. Further, it is hoped that a complete analysis can be made of the resistance displayed by California mosquitoes to toxicants. This project may also undertake to establish the relationships between temperature variations and the action of toxicants on mosquitoes. The toxicant investigations project will employ a professional person to direct a study of the development of new toxicants for mosquito control through field tests of those materials which show promise as a result of laboratory studies. Plans are being made to expand this portion of the program with the assignment of additional personnel through the Bureau of Vector Control, and through wider participation by the mosquito abatement districts in the Central Valley. Thus, in 1951, there is to be an all-out attack on the problem of selecting the right toxicants for mosquito control in California.

DISCUSSION

The approach, both administrative and technical, being used in the study of the biology of mosquitoes important to control programs in California has been presented. It is too early in our work to be able to give much in the way of conclusive data. It is not expected that all of the biological principles learned through this program will have immediate application. All persons engaged in long range mosquito control activities have come to realize that biological investigations have their place in the mosquito control program, and it is with a progressive outlook toward the future of mosquito control in California that these cooperative studies have been established. The results of these studies are not for the benefit of single districts but will have application in the programs of all the districts of this state, and may well provide basic scientific facts useful in the mosquito

abatement programs throughout the country and elsewhere in the world.

Conclusions

Investigations have been initiated aimed at evaluating present mosquito control methods and developing new methods. This will take the form of a large-scale, all-out attack via the biological approach, the results of which are expected to increase efficiency in California mosquito control procedures.

MOSQUITO CONTROL ON A COMMUNITY-WIDE BASIS

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Health and comfort—at surprisingly economical cost—can be achieved on a community-wide basis through modern mosquito control. Scores of U. S. communities have learned this in recent years. There is increased interest in such control, and in the methods to achieve it.

Prior to the introduction of DDT the main effort of most communities in mosquito control was the application of oil or other larvicide to mosquito breeding ponds in and around the area to be protected, or drainage and filling operations so far as practicable. Such procedure, although resulting in a fair degree of control, at times was largely offset by the adult mosquitoes drifting in on prevailing winds from surrounding untreated areas. That has indeed been the experience at Fargo, where larviciding operations were continued for years, but have of late shifted over almost entirely to the application of DDT for the primary purpose of controlling the adult mosquitoes.

The predominating species of this area are *Aedes vexans* and *A. dorsalis*. They constitute about 75 per cent of the mosquito population. They are noted for their flight dispersal ability and are regarded with particular concern as important vectors of encephalitis. Others of the 31 species recorded by Post and Munro [4] (1949) as of lesser consequence but troublesome at times are *A. sticticus* and *Culex tarsalis*.

Heretofore, DDT has been applied to the residential and park areas of Fargo by means of ground operated sprayers or fog machines. In 1950 a serious invasion of mosquitoes and blackflies, and scattering infestations of cankerworms prompted an application of DDT by airplane because of its speed of coverage as compared with ground operated equipment. Although mosquitoes are controlled by ½ pound of DDT per acre it was decided to make the application sufficiently heavy (1 lb.) to control the other pests mentioned.

The application was made during the period June 13–15. A local aerial spray agency, which used the Stearman type of biplane equipped with a spray boom mounted underneath the lower wing, furnished the materials and made the application. A total of 1,500 acres, comprising the residential area of Fargo and adjoining parks, was covered with the spray at the rate of 1 lb. of actual DDT per acre at a total cost of $3,000.00. This, on the area basis, represented a cost of $2.00 per acre; or, on the basis of the 38,000 population of Fargo, about 8 cents per person.

The blessed anonymity of the research scientist was denied in this spraying

[1] Entomologist
[2] Associate Entomologist
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[4] Post, R. L., and Munro, J. A. Mosquitoes in North Dakota. *Bimonthly Bulletin*, 11 (5): 173–183, 1949.

operation. On the contrary, attention of the entire community was focused on the project. Radio stations and daily newspaper headlines told of the steps leading to the community-wide spraying. Everyone in the community was on the alert to praise or condemn—every outlying resident with a hive of bees, every old maid with a pet cat, every amateur ornithologist, entomologist, botanist and zoologist had opportunity to take notice of this operation. It was as obscure and reticent as a circus parade.

The control achieved was spectacular. Within 24 hours following the aerial application, in all portions of the city and its parks the mosquito and blackfly population had dropped from what were considered serious infestations to negligible or almost zero populations. The cankerworm infestation was also controlled.

Possibly because this was the first aerial insecticidal coverage of Fargo, the results were watched by the people with particular interest. Some concern was expressed that the 1 lb. rate of DDT might have an injurious effect upon gold fish in lily ponds, bees and other beneficial insects and birds. This had been anticipated in that trained observers spent considerable time both before and after application of the treatment to determine the possible effect of the DDT on these forms of life.

Examination of a lily pond containing 26 goldfish on which the aerial spray had fallen showed no mortality of the fish. To the owner's surprise the fish continued to remain healthy and active throughout the season. No reports were received from anyone of DDT injury to goldfish in other pools.[1]

There was no evidence that the spray had had any effect upon honeybees. It should be mentioned that at the time of the application most of the bee pasture then available was in fields outside the area of treatment. There was, however, a 15 per cent mortality of ladybird beetles observed, also an apparent reduction in the number of bumble bees. It was difficult to ascertain the bird population with any reasonable degree of accuracy. Shortly following the application of DDT the birds shifted their feeding location from among the branches where they had previously fed to the ground to feed on the fallen and dying cankerworms. No dead birds as a result of the spraying were observed in a careful inspection throughout the park and residential sections of Fargo covering a period of the week following the application. It should also be mentioned that although the citizens of Fargo were on the alert to observe and report any injury which might result from the application nothing of a serious nature was reported. The most serious were reports of automobiles being speckled by the spray which was easily remedied by washing. There was also some objection expressed to the plane flying at a low altitude over the housetops, but as the pilot had obtained the necessary permission from the Civil Aeronautics Commission he was not subject to censure.

A program such as this requires careful planning, also securing the cooperation of the various agencies which can help. The city officials, civil aeronautics, experiment station, radio and press—all had important roles in the project. All agencies cooperated.

The planning took into account financing, whether it would be municipal funds, public subscription, or donations. Timing of the application was considered vitally important. The insecticidal application must be made neither too early nor too late and at the proper rate. The application should be made only under favorable weather conditions.

The success of the program was attested by hundreds of congratulatory phone calls by people in Fargo who felt that the aerial application represented a very worthwhile spending of public funds.

[1] A subsequent aerial application of DDT at the same rate (1 lb. per acre) made in August 1950 resulted in killing 2 per cent and 16 per cent of the goldfish in two pools respectively according to the owners' reports.

RECLAIMING RIVERBOTTOM LAND IN CONTROLLING *AEDES VEXANS* IN THE LODI, CALIFORNIA AREA

ROBERT H. PETERS

Manager, Northern San Joaquin County Mosquito Abatement District

The Northern San Joaquin County Mosquito Abatement District located in the central part of California has a general mosquito control problem similar to other districts in this region of the state. To date some 17 species have been the target of our efforts over an area of approximately 200 square miles.

However, a special problem area in the form of the Mokelumne River bottom lands was found to produce hordes of mosquitoes particularly during the late spring and early summer snow-melt runoffs. Entomological checks have revealed the presence of three *Aedes* species: *A. vexans, A. sticticus* and *A. increpitus,* of which the greatest number have been *A. vexans.*

On the advice of Mr. Ernest Campbell, initial manager of the district, our Board of Trustees was quick to realize the values of inaugurating a permanent control program in this river area which was covered for the most part with an impenetrable jungle growth varying in width from a few hundred feet to more than a half mile in places. This intermittent jungle extends along the twisting Mokelumne River for approximately thirty (30) miles following an east-west pattern through the most populated areas in our District.

For the benefit of any skeptics it should be pointed out that this jungle cover has thrived for scores of years. Tree growth includes oak, cottonwood, poplar, ash, willow and locust, some with diameters to over six feet; smaller growth includes the wild grape, berries, roses, nettles, poison oak, tules and numerous other weeds and grasses. Human penetration is virtually impossible except with a machete or similar blade.

In the fiscal year 1945–46 our cooperative mosquito control and reclamation program was begun with the acquisition of two D-7 Caterpillar tractors equipped with 13½ foot blades and two 12-yard carry-all scrapers. This phase of the program was set up on a cost basis which was supported entirely by funds derived from work done by District equipment. The scope of this work, apart from the mosquito control aspect, includes reclamation of this potentially fertile river bottom land to agricultural or other useful purposes. Since these lands are improved for the individual with a consequent increase in real value it was concluded that tax monies could not be justly used except in rare instances for this type of work. As such, this work has successfully operated on this basis for the past five years and this unique approach has attracted considerable interest as a sound method of permanently eliminating the sources of *A. vexans* while beneficially reclaiming land.

Needless to say, this is a long term program and much repetitive work must still be done in conjunction with the heavy equipment work along the river; however, each year finds the problem simplified and the day will sometime come when the river bottom will cease to be the source of countless mosquitoes and a very costly control problem will be eliminated.

Steps taken in this land clearing program involve the following:

1. *Survey and recommendation to land owner:* This is generally done by the manager in conjunction with the Senior Operator to ascertain the area involved and estimate the work required in line with the anticipated use of the reclaimed land. When desired, maps or sketches of proposed work are submitted to the land owner; and work agreement forms are signed.

2. *Brushing:* This involves the open-

ing up of the area by the tractor operators with their blades which remove all growths including trees up to about a foot in diameter which can be felled without digging out.

3. *Digging around trees:* This step prepares the trees for felling and loosens the soil to enable the trees to be removed in their entirety (including the roots).

4. *Tree felling:* With the soil loosened the trees are felled by pushing the medium sized trees over with one or both tractor blades. However, the larger trees must be felled by cable in which both tractors pull the trees down. This step involves the use of a cable crew who raise the cable to sufficient height to provide leverage to down the larger trees.

5. *Piling and disposal of trees:* While some of the oak trees are removed and sawed up for firewood, the majority of brush and trees having no value are piled and allowed to dry where they are later burned. In some instances, however, these larger trees are lined along the levee in order to provide a buffer for high water flows.

6. *Filling and rough levelling:* Both the blades and scrapers are used in this step where the land is levelled to eliminate the holes and swales which at one time were the source of our *A. vexans*.

7. *Leveeing the river bottom land:* This, the final step completes the work on the greater part of the cleared land except where the land is utilized only for pasture. Although some variations exist, the levees constructed average a twelve foot crown with a three to one slope on the river side. Levee placement is an important part of the job since allowance must be made for maximum river flows. Compaction with the scrapers in the process of construction produces a satisfactory dirt levee.

To date the Northern San Joaquin County Mosquito Abatement District has completed the following types of work in our cooperative program.

1. Cleared approximately six hundred (600) acres of land along the river bottom where crops of tomatoes, beans, peas, sugar beets, corn, melons, squashes and grains have replaced the previous mosquito-infested jungles.

2. Constructed approximately 7½ miles of levee surrounding these fertile river bottom lands.

3. Constructed two groups of winery sumps, and disposal ponds; one group of cannery waste disposal ponds; and one group of effluent disposal ponds for a sewage treatment plant. All of these are continuous sources of *Culex* mosquito development and as such were designed and constructed with accessible jeep roads for control purposes.

In addition, a plan for the enlargement of the Lake Park of the City of Lodi, to include a possible two miles of this heretofore uncleared river bottom land, is being considered on a cooperative basis between the city and our Mosquito District.

Although it is apparent that the cost per acre for this type of land reclamation will vary, dependent upon many factors such as thickness of cover, number of trees to remove, size of holes to be filled, size and length of levees to be built, etc., the following information can be presented.

1. The real value of these river bottom lands has increased in value from about $75.00 per acre to $300.00 and more per acre after clearing and leveeing.

2. Costs for clearing, rough levelling and leveeing these river bottom lands have ranged between $125.00 to $150.00 per acre. This represents from 25 to 30 tractor hours per acre at a rate of $5.00 per hour.

3. Levee construction has averaged from 90¢ to $1.00 per running foot.

4. Rates of operation are about half the commercial rates for similar equipment.

This program has been designed to cooperate with, rather than compete with private enterprise in the heavy equipment field and it is our opinion that we have aided private contractors rather than interfered with free interprise. Since our equipment is restricted to areas where the mosquito problem justifies its use and

since we terminate our efforts with hole filling and rough levelling, it is apparent that every acre of ground cleared is another acre opened to private enterprise for finish levelling or agricultural preparation.

There is no question in the minds of our trustees that a great measure of the success of this permanent control program is attributable to the efficiency and close working harmony of the operators of our heavy equipment who have acquired a specialty in this type of work.

In summarizing this phase of our program we can only say that this course of permanent mosquito control work supported by the land owners themselves is the most sound means of eliminating a costly yearly control problem. Particularly with the present rise in cost of insecticides and the apparent resistance of certain mosquitoes to some insecticides, we feel that real economy is effected when we eliminate the source of our river bottom mosquitoes.

A BIRD'S EYE VIEW OF MOSQUITO EXTERMINATION IN AND AROUND WINNIPEG AFTER THE FLOOD OF 1950

DR. H. M. SPEECHLY [1]

President and Chairman, Greater Winnipeg Anti-Mosquito Campaign

This is in no sense a highly technical discourse. It begins with a brief picture of the geography of the Red River of the North, and my first remark is that Winnipeg, the capital city of the Province of Manitoba, derives its name from the Indian word "Winnipic," signifying "Muddy River." That describes the Red River exactly, but why this more aesthetic name was given to our river I cannot tell. However I do know that in the spring when the grass grows green upon its banks its muddy waters take on a reddish tinge.

I can hear somebody say, "But why 'Manitoba' as a name?" Back in the early 1880's we boys at school in England were told by a gallant Protestant missionary, Bishop Horden, that the name is a Cree compound of two words—Manitou "the Great Spirit" and Ba "the Country." I am free to admit that such a view of Manitoba is justifiable in early June before mosquitoes buzz, but dubious in mid-January!

I rather fancy that a good many of our mosquito controllers here present have only a vague conception of the geography of the Red River, even though it begins its existence as the small Ottertail River in Minnesota and then takes its usually lazy tortuous course for 300 miles north to become the western boundary between Minnesota and N. Dakota right up to the 49th parallel which is the International Boundary between the U.S.A. and Canada. After passing through Fargo and Grand Forks it gathers some volume and strength from a dozen or more insignificant looking tributaries but capable in some springs of rising to a surprising height and flooding alarmingly along its shallow valley. It crosses the International boundary at Emerson in Mani-

[1] Read by E. J. Stansfield, Assistant Manager. As noted in the March issue of *Mosquito News*, Dr. Speechly died on March 17, 1951. The present paper is one of the last—possibly the last—of his contributions to the literature on mosquito control. We note, in presenting it, that even here, in a factual treatment of serious moment, something is present of the genial personality and refreshing wit that made Dr. Speechly so well beloved among his colleagues in the AMCA.

toba and then wriggles 100 miles straight north through Winnipeg to the south end of Lake Winnipeg where its marshy delta lies several miles west of the more impressive entry into Lake Winnipeg of the nobler stream of the Winnipeg River. In this last stretch the Red River receives another half dozen tributaries, the largest of which, the Assiniboine, joins the Red in the heart of Winnipeg City.

I will now quote from our City Engineer, W. D. Hurst's excellent report.

"Greater Winnipeg has undergone six major and five minor floods since 1826, a major being defined as one where the water level exceeds 24½ feet above average ice level, thus:

"In 1826 the Red River reached 36½ feet above ice level.

"In 1852 the Red River reached 34¾ feet above ice level.

"In 1861 the Red River reached 32½ feet above ice level.

"In 1850 the Red River reached 30⅓ feet above ice level.

"In 1882 the Red River reached 26 feet above ice level.

"In 1904 the Red River reached 24⅔ feet above ice level.

"In 1948 the Red River reached 23½ feet above ice level.

"In 1950 the Red River reached 30⅓ feet above ice level.

"The conditions giving rise to a major flood are definite after this manner:— (1) A wet fall, (2) an early winter, (3) heavy snowfall during the winter plus low temperatures, (4) a late sudden spring break-up, (5) cloudy rainy weather during the spring run-off, (6) similar conditions affecting the Red and Assiniboine Rivers. Except that there was very little snow in the Assiniboine Valley all the factors prevailed in early May, 1950. The Assiniboine River was only shouldered back by the Red River at their confluence for a distance of about 3 miles. Although the flooded area within the city was only about 7 per cent of the city the effects of the flood extended over the entire city through the backing up of the sewerage system."

The Spirit of Cooperation Wins. In presenting this report just before the opening of our 25th season of continuous mosquito control we look back proudly upon the splendid support given to the Greater Winnipeg Anti-Mosquito Campaign of 1950 by the joint cooperation of the Federal Government, the Province of Manitoba, and the City of Winnipeg in using our campaign executive as the spear-head for the successful attack on an expected plague of flies and mosquitoes. This plague was certain to follow the flooding of Winnipeg and the Red River Valley if nothing was done. As usual the campaign executive was ready in April to deal with mosquito control long before the flood was ever feared. Never were we better equipped, owing to foresight. We had a two-ton truck and a half-ton truck, a Buffalo Turbine sprayer, two Tifa foggers of our own, and knew where we could hire two more if necessary. Two breweries combined to present us with the one Tifa, and with the material aid of the T. Eaton Co. we were able to buy another. Larval development was later than usual owing to the cold rainy weather, as proved by our field inspection during the first week of May, but we covered certain city areas on the north and west flanks of the city. Suddenly the flood came down upon us from Minnesota and N. Dakota where heavy snowfalls and rain had just fallen. It was on May 8 that the City Engineer requested the use of our trucks and squad of 17 men. This we gladly did and as we manned our own trucks, we nursed them carefully and safely through the emergency. Thus, after May 18 they were in good working order for our normal occupation. Just at that critical time an Ottawa doctor arriving by air to lecture to the Medical Society described the appearance of Winnipeg as an island surrounded by water.

We soon found, as the flood subsided, that no larvae were present in the deep flooded area, but that on the perimeter and from outwards a flight of mosquitoes increased so rapidly that in the first week of June we began to fog. Normally

fogging would not be needed till late in June, but we did not make the mistake of relying on fogging. We put our hand-sprayers and the Buffalo sprayer to work on areas showing larvae as usual.

Finance. Our financial position was such that, until the more complicated method of extracting funds from the Federal Treasury by the Provincial Department of Health and Welfare was established, we had to depend on the city grant of $10,000.00 (which was increased in August by $1,500.00) and a sum of $978.00 subscribed by suburban municipalities. In fact, it was not until the end of June that we learned that the Federal Government had granted the sum of $29,500.00 for fly and mosquito control for Greater Winnipeg and parts of the Red River valley. This estimate was arrived at by the Provincial Department based on the advice of our Assistant Field Manager, E. J. Stansfield, who was eventually placed in control of the whole of our mechanized operations in Greater Winnipeg. In all these preliminaries we were indebted to the cooperation of the Hon. Ivan Schultz, K.C., Provincial Health Minister, and his Director of Sanitation, Hugh Malcolmson, M.D. Further, a separate office with telephone and stenographer was placed at Mr. Stansfield's disposal for the duration of the campaign as well as convenient parking spaces for our vehicles.

Another phenomenon of unusual import occurred. We were visited by no less than six entomologists at the instance of Dr. Robert Glen, Chief, Division of Entomology, Dominion Dept. of Agriculture at Ottawa. In 1927 and 1928 we had the support of Dr. A. Gibson, then the Dominion Entomologist and his Assistant, the late Eric Hearle, M.Sc., who was then the leading mosquito expert in Canada. Before World War 2 we drew upon the Senior Science students of the University of Manitoba for our supply of Field Managers, but only one of these able young men was bitten with the entomological side of mosquito control. Our first Field Manager, Jack Tully, dallied with it, but John McLintock, M.Sc., after serving with us for three years was the only one who really specialized in mosquitoes. It was a happy thing for us when we learned that he was commissioned to spend a week with us, because owing to his past association with our campaign we knew we would get his sympathetic knowledge of our problem. His advice was of great practical value. In addition we appreciated Dr. R. Glen's suggestion that Dr. C. R. Twinn, Director of Household and Medical Entomology with Dr. A. W. A. Brown, Professor of Zoology, Western University of London, Ont., both experienced in Arctic Mosquito Control should inspect and report on our campaign. They also directed the splendid work done by two R.C.A.F. planes piloted by pilots experienced in Arctic control work. They covered very thoroughly the north, south and west districts outside the built-up areas and along the river banks. We also were inspected by three field officers, Messrs. D. G. Peterson, D. Watson and P. Morrison. To quote one of these six entomologists, "this was the first time in Canada that mosquito control by space spraying had been attempted over so large an urban area." Actually the area covered by this project as a whole included approximately 250 square miles. In addition we engaged the services of a private firm, Hastings and Sons Ltd., to spray by a Tiger Moth plane certain parts of the river banks. During this interesting period Field Manager George Kurdydyk attended to careful ground inspections, spraying and improving drainage ditches all round the city.

Over-all Fogging. By the time the expert entomologists had completed their task we had arrived at the beginning of July, just when flies began to appear and the "foreign" mosquitoes began to raid the city. McLintock's advice was to fog thoroughly as often as necessary every street and lane in Greater Winnipeg. The total distance covered was 2,654 miles, often at a speed of 10 miles per hour. Mr. Stansfield used a squad of six intelligent

young men to ply three Tifa foggers. He himself by dint of strict overseeing of this tremendous job during the whole of July and August ensured its complete success. In our climate when the wind speed is less than 8 miles per hour the best fogging time is between 7 p.m. and 7 a.m. This involves considerable loss of sleep in bed for the field manager who had the human element to direct, the remedying of machinery defects, and the care of much bookkeeping. Carelessness in directing fogging in relation to trees, shrubs, vegetables, flowers, bees and fish must be avoided, and on occasion the irascible type of citizen, male or female, must be met and pacified. All these our field manager handled with unfailing good temper and judgment. Nor was he satisfied with land operations but assumed a naval role by mounting a Tifa on a suitable power boat from which he successfully fogged some 24 miles of trees and bush-lined banks of the Red and Assiniboine Rivers.

Hence it came to pass that universal approval and satisfaction was widely expressed for the complete victory over the winged barbarians. With regard to the common fly we had certain areas associated with industrial plants, certain lanes and stables which required vigorous DDT application to rid them of flies.

Outside Greater Winnipeg six small riverside towns were visited by John McLintock who advised the use of a Tifa fogger for residential districts and hand sprayers for breeding areas. DDT in oil solution was supplied for the purpose by the campaign. Excluding these towns the total area covered by the Greater Winnipeg Campaign included ten suburban municipalities and parts of three others, a coverage of approximately 250 square miles. During the past 24 years we have always maintained that just such a campaign would secure freedom from the mosquito pest. This has been achieved by adequate finance and the use of mechanical sprayers manned by intelligent operators in the 1950 campaign.

A NEW TYPE OF LARVICIDE FOR SPECIALIZED MOSQUITO PROBLEMS

LEROY KINSEY

Deputy Commissioner, Nassau County Department of Public Works, Mosquito Control Division

We, in mosquito control work, are always searching for better methods of control. Sometimes a new and better larvicide is discovered in the course of trying to solve a particularly stubborn problem. These problems present a challenge leading to experiments which often go beyond the demands of routine operations.

Such a problem has existed in Nassau County in connection with the use of abandoned sand pits as public dumps. One of the most troublesome of these is located adjacent to a large housing development. Children use the pit as a swimming hole and several have drowned. Authorities were forced to fence in this area to prevent trespassing. They have been trying to reclaim the pit by filling it with refuse that is not incinerated such as grass cuttings, brush, trash, ashes, discarded building materials, etc.

This particular pit comprises an area of about 11 acres and has banks which slope steeply some thirty feet to the surface of the water. The water in the pit covers an area of five acres and varies in depth from 45 to 50 feet. More than 10,000

truck loads of refuse are dumped annually along the banks of the pit and pushed into the water by a bulldozer. Consequently, two very favorable conditions for breeding exist. The water is covered with flotage which restricts wave action, and the decomposition of organic matter contained in the refuse provides ample food supply for the mosquito larvae.

During past breeding seasons the larvicides used were ineffective. In the season of 1949, from May to September, a total of 153 gallons of 30 per cent DDT-oil concentrate (382 lbs. of technical DDT), 2,600 gallons of fuel oil and 45 gallons of 25 per cent DDT emulsion concentrate (95 lbs. of technical DDT), were applied at the rate of 0.05 ppm in weekly treatments. These larvicides were sprayed from a scow, equipped with a motor-driven high-pressure spray pump, having a discharge rate of approximately 50 gal. per hour. Despite the weekly applications, a high percentage of *Culex pipiens* larvae was found five to six days after the application, and the emergence of adults continued all during the season, infesting the heavily populated residential area for at least a two-mile radius. The use of aerosol adulticides, dispersed twice weekly during the summer months within the infested area, gave only temporary relief lasting a few hours.

It was evident then that the most likely means of controlling this source of *Culex* breeding was to find a stable larvicide. The DDT emulsions used were unstable, and the oil solutions were dissipated too rapidly to remain effective. Many inquiries were made in trying to secure a stable larvicide. Finally one was located which proved to be most effective. This larvicide is manufactured by the Chemical Insecticide Corporation, Brooklyn 15, N. Y.

Accordingly, in the season of 1950 a 50 per cent chlordane emulsion containing 5.25 lbs. of technical chlordane per gallon was used. The specifications of the manufacturer stated that a 2 per cent dilution of this emulsion with water would remain stable for a period of one year. This material acted differently from the other larvicides mentioned earlier. This special 50 per cent chlordane colloidal concentrate, when diluted with water to strengths as low as 1/10 ppm formed a mixture which because of its unusual stability, clarity and penetrating qualities was dispersed throughout all the water in the pond. The toxicant could not be distinguished from the main body of water, and unlike the ordinary larvicides did not fall to the bottom or float to the top upon standing. These characteristics enable us to control the breeding of mosquitoes throughout all parts of the pond where they were in contact with water.

The first treatment with this larvicide was made on May 22 at an application rate of 0.2 ppm, requiring 1,000 gallons of a 2 per cent dilution. Thereafter, routine inspection checks were made weekly. No mosquito breeding developed during the months of May, June and July.

On July 17, a second treatment was made as a precautionary measure due to the increase in refuse disposal during the summer and the accumulation of open receptacles among the flotage.

These two treatments were sufficient to prevent mosquito breeding during the season of 1950 from May to October, with one minor exception. On August 25th, after a heavy rainstorm, larvae of *Culex pipiens* were found in a small area of some 500 sq. ft., adjacent to a part of the pit bank where a considerable quantity of earth and broken concrete had been bulldozed into the water. This new crevice, holding water, naturally had not been treated. An interesting point in connection with this incident is that the area mentioned was treated with a 2 per cent DDT emulsion upon the discovery of the larvae as our stock of chlordane had become depleted. Larval breeding occurred again a week later. When our stock of chlordane was replenished, a 2 per cent emulsion was used and no larvae were found thereafter.

The chlordane used in 1950 cost only $11.00 more than the materials which had been used unsuccessfully in 1949. How-

ever, in 1949 it required three men to make 17 applications which produced no results. In 1950 it took the three men only four days to make the application of chlordane emulsion, this time with very favorable results.

In conclusion, chlordane has proved to be more effective than DDT in this particular control problem. The cost has been about the same as DDT but the labor costs have been considerably less. Because of the scarcity of DDT and its prohibitive cost, chlordane larvicide is being adopted in Nassau County for the coming year as the basic larvicide. It is planned to continue experimenting with it and to test its effectiveness in controlling *Mansonia perturbans*.

MOSQUITO CONTROL WORK IN PORTLAND, OREGON AND VICINITY IN 1950

ARTHUR H. WOODY

Insect Abatement Supervisor, Bureau of Insect Control

The first serious attempt at mosquito control in the Portland vicinity came in the middle 30's. In 1934, a study was made by the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, with Entomologist H. H. Stage in charge. Results showed that the *Aedes,* or floodwater mosquitoes, were much more than a nuisance. Their presence caused losses running into thousands of dollars through decrease in milk production in dairy herds, inability to hire or keep labor in the truck crop area, and loss of tourist trade.

There are 34 species of mosquitoes known to occur in Oregon. They belong to 5 genera; *Aedes, Anopheles, Culiseta, Culex,* and *Mansonia.* Out of 34, we have nine species that are plentiful enough to warrant control. They are:

A. 1. *Aedes vexans* Meig
2. *Aedes sticticus* Meig (formerly known in this area as *lateralis* Meig)
3. *Aedes increpitus* Dyar
4. *Aedes dorsalis* Meig.

These species are found in the overflow areas along the Columbia and Willamette Rivers.

B. 5. *Culex tarsalis* Coq.
6. *Culex pipiens* Linn.
7. *Culiseta incidens* Thompson.

These species are found in semi-permanent and impounded bodies of water.

C. 8. *Anopheles punctipennis* Say
9. *Anopheles freeborni* Aitk.

These species are found in spring-fed lakes in both Multnomah and Clackamas County.

With Federal aid, extensive brush clearing of the mosquito breeding areas was done in 1935. When the floodwaters passed over these areas, oiling crews sprayed diesel oil on water where larvae were hatched. Since this work was done by rowboat or on foot, it was impossible to treat all the hatching areas. Indeed, only an estimated 25,000 out of a possible 80,000 acres were treated.

The work was continued until 1938, when Federal aid was withdrawn. By that time residents of Portland and Multnomah County had become aware of the advantages of mosquito control and protested its discontinuance. So the City of Portland and Multnomah County consulted to see what they could do, and be-

tween them, they budgeted $10,000 per annum for the continuance of the work, and the same sort of control program was carried on, but without brush clearing and otherwise in a more limited way. During the war years, however, mosquito control bogged down owing to the limited budget and rising costs.

In 1944, a dump truck and a power pump were acquired for use in control work. The following year, Mayor Lee initiated steps to establish the Bureau of Insect Control with mosquito control as its major problem.

In 1946, three flights were made with an Army bomber, experimenting with the dispersal of insecticide from aircraft. One thousand two hundred gallons of 25 per cent DDT concentrate cut to 5 per cent in diesel oil were used and a total of 3,000 acres was covered in 3½ hours of flight time. The results obtained were practically 100 per cent control for this area. It would have taken ten men 22 days using the usual method of spraying by hand from knapsack sprayers.

The City of Portland, therefore, went ahead with plans to use this type of control in the future, and early in 1947 purchased two surplus trainer planes and equipped them with thermal exhaust aerosol units and spray booms from plans developed by the Tennessee Valley Authority and the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

During the past four years, through the use of aircraft and other improvements, the mosquito problem in Portland and Multnomah County has become sufficiently well controlled to result in fewer and fewer reports of the presence of mosquitoes, particularly of the *Aedes* species.

The areas under mosquito control extend over a total of approximately 150 square miles covering not only Multnomah County, but other counties which contract with the City for control. In 1950, these counties were Clackamas in Oregon and Clark in Washington. Control is carried on not only in all areas affected by the spring and summer run-off of the Columbia and Willamette Rivers, but also impounded water areas, drainage ditches, artificial water bodies such as duck ponds and water hazards on golf courses. In the 1950 season, 78,000 acres were controlled by aircraft and 2,360 acres with ground equipment.

This year, it was necessary to carry on active *Aedes* control operations for a longer period than in prior years as the flood condition of the Columbia and Willamette Rivers continued for a period of 68 days, compared to a normal period of 35 days. Seven complete coverages of the breeding areas in Multnomah County were required using 27,180 gallons of oil and solvents and 16,121 pounds of chemicals. The Bureau aircraft flew a total of 456 hours and 18 minutes.

Due to the longer summer season, *Culex* and *Culiseta* mosquitoes were found in greater numbers than in prior years, indicating that climatic conditions play a large part in control operations. Because of the international situation which might cause a critical shortage in some of the necessary chemicals needed in control work, we deviated from our normal operations and carried on an experimental project under the supervision of C. M. Gjullin, Research Entomologist attached to the U. S. Bureau of Entomology and Plant Quarantine stationed at Corvallis, Oregon. In an attempt to find a non-critical insecticide which could be used for mosquito control, it was found that Nopco 1216 mixed at the rate of one gallon of Nopco to ten gallons diesel oil applied at the rate of two gallons per acre by aircraft gave excellent control.

The principal chemicals used were DDT and pyrethrum extract. These were blended in aromatic solvent 42, diesel oil and black oil, not exceeding 5 per cent DDT and 1½ per cent pyrethrum, dispersed at the rate of two quarts per acre. This combination gave a truly surprising control, both as a larvicide and adulticide. Complete toxicological data given by the manufacturers show that pyrethrum can be used in combination with DDT in these percentages without any added toxic

hazard to human beings or warm blooded animals. The diesel oil used meets Federal Specification V-K-211A, having a specific gravity between 0.824 and 0.795 at 60° F. The black oil used is a pure petroleum product free from fatty oils, fatty acids, resins, soaps or other non-hydrocarbons, sediments, and sludge. Aromatic solvent 42 is methylated naphthalene, specifications for which can be obtained from U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

The Bureau of Insect Control owns and operates a North American AT-6 equipped with a 600 h.p. Pratt and Whitney engine, which has been converted to a spray plane. Controls and instrument panels were removed from the rear cockpit and a 96 gallon tank fabricated and placed in position directly in back of the pilot's seat in the front cockpit and resting one inch beyond center of C/G line. A 12-volt electric driven pump was constructed and mounted on fuselage members directly beneath the tank. The boom is 42 feet long, mounted nine inches below the wing surface. It is attached 3½ inches behind the leading edge at the wing tip diagonally to a point directly beneath the fuselage at the trailing edge of the wing. Nozzles are spaced 12 inches apart, using Chicago Spraying Systems diaphragm T-jets with No. 6510 tips. T-jet diaphragm valves open at five pounds PSI. The operating pressure of the system is 40 pounds with a dispersal rate of 18 gallons per minute at 133 miles per hour, applying two quarts to the acre at 50 to 75 foot levels. This plane was operated the entire season of 1950 without mishap or breakdown in the spray system and has proved to be a very satisfactory airplane for the type of area that we control here.

We also had a Boeing PT 17 equipped with a 220 h.p. engine with an exhaust stack five inches in diameter installed lengthwise of the fuselage. A 2½ inch venturi is attached to the end of the 17-foot stack with two Monarch .0015 spray nozzles projecting into the venturi throat with a distributing rate of 5.5 gallons per minute at 70 miles per hour. A 70 gallon insecticide tank of tear drop design is mounted on bomb shackles beneath the fuselage of the plane with a wind-driven Overdorfer bronze gear pump mounted on the under-carriage. This airplane, while being very efficient in small, level areas, has been very high on maintenance. A breakdown on operational costs between the Boeing and North American, this past season, showed that while the North American used much more gasoline, it did three times the amount of work that the Boeing did. We disposed of the Boeing and have recently purchased a Douglas A-25, which is an all-metal airplane of approximately the same design as the North American and will be equipped with the same type of dispersal system.

As we are operating from a fixed base at the Portland-Troutdale airport, it became necessary for us to purchase a tank truck, which is a four-wheel drive truck with an 1,850 gallon tank. This is used to transport insecticide from our mixing plant to the airport. For our ground control work, we have a Lawrence Aero-Mist, a Hardy Sprayer, and a high-velocity Friend Duster.

We have found it advisable to obtain the following meteorological data before conducting spray flights:

1. *Relative Humidity,* which is determined by the use of a sling psychrometer.

2. *Wind Velocity,* which is determined with the aid of an anemometer, as aerial spraying cannot be done with wind velocity exceeding four miles an hour.

3. *Conversion and Inversion Temperature Conditions,* determined by placing one thermometer one foot above the ground and another thermometer six feet above the ground, a difference in temperature indicating whether the air is rising or falling. For airplane spray application, inversion temperatures are most desirable, as the settling rate of spray particles in still air is proportional to the square of particle radius, according to Stokes' law, which is applicable to spherical particles of less

than 300 microns diameter. However, in the wake of an airplane, there exists a pronounced downdraft which imparts to spray particles settling velocities which are greatly in excess of the velocities indicated by Stokes' law. A 50-micron droplet of 5 per cent DDT solution will settle in still air at about 17 feet per minute, while in the wake of an airplane it has a downdraft of 600 feet per minute. This factor is of greatest importance in the deposition of fine spray droplets. Satisfactory spray results with minimum dosages can be secured only under the proper meteorological conditions of still air existing at dawn and dusk, when breezes are at a minimum and inversion conditions exist.

Starting last year, ground markers were placed indicating areas and swaths so the pilot can locate areas and treat them with minimum loss of time. Radios have also been installed in the aircraft so that they can be in communication with the tower and also with a Bureau automobile which, too, is equipped with radio, eliminating the necessity of employing flagmen. This arrangement provides an increased measure of safety, as in an emergency the pilot can communicate directly with the Bureau and vice versa.

We have had a very successful mosquito control this past season and hope to achieve the same degree of control this coming year.

EQUIPMENT AND MATERIALS USED IN CONTROL OF GNATS IN CLEAR LAKE, CALIFORNIA

ARTHUR W. LINDQUIST and A. R. ROTH

U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine

The Clear Lake gnat, *Chaoborus asticotopus* D. & S., has been a source of annoyance to the residents near Clear Lake in California for many years. The gnats do not bite, but enormous numbers flying around lights and into houses on summer evenings cause distress and discomfort. Outdoor gatherings and activities are all but impossible.

Research by the Corvallis, Oreg., laboratory of the Bureau of Entomology and Plant Quarantine indicated that several of the chlorinated hydrocarbon insecticides were effective in killing gnat larvae. One of the compounds, TDE (dichlorodiphenyl dichloroethane) was selected as having exceptional promise because it was relatively nontoxic to fish. Tests in two small lakes (Lindquist and Roth, 1950) gave encouragement that a TDE emulsion could be used safely and that the gnat might be controlled in Clear Lake. The emulsion concentrate contained 30 grams of TDE, 10 ml. of Triton X-100, and 72 ml. of xylene.

The Board of Trustees of the Lake County Mosquito Abatement District were willing to proceed with a control project on Clear Lake. The County district financed the operation with assistance from the State of California through the Bureau of Vector Control. The writers worked out plans for applying 14,000 gallons of the insecticide over the lake.

Clear Lake covers an area of approximately 40,000 acres, and has a water depth up to about 65 feet in a few places. The shore line is about 150 miles and the greatest distance across is about 8 miles. Frequent storms creating heavy wave action had to be considered in making plans for size of boats and barges to be used.

Studies by the writers had shown pronounced subsurface currents running in a somewhat circular pattern in the large arm

of the lake. The submerged currents could be detected when the lake was calm, and were probably set in motion by evening winds striking an exposed 5-mile section of the southeast shore line obliquely. Even small waves striking other parts of the shore caused outward moving currents. These findings plus the knowledge that the emulsion would disperse naturally in water led to a belief that if the insecticide was applied in narrow swaths separated by several hundred feet it would be rapidly dispersed throughout the water and stay suspended for several days before sinking. The larvae are embedded in the bottom mud during the daytime, but at night they migrate into the upper water. It was therefore believed that they would receive a toxic dose of the insecticide over several nights' exposure.

In order to have the maximum concentration of insecticide on the large arm of the lake, it was necessary to apply the material in one day. If application would be made over several days' time, the required concentration would never be reached because of settling out and deterioration of the toxicant. This arm of the lake was laid out in six sections, each 1 mile wide. Four round trips, or eight swaths approximately 700 feet apart, were made on each section. The insecticide was discharged by gravity flow direct from 50-gallon drums. A discharge rate of one drum in 20 minutes was obtained by laying the drum on its side and allowing the fluid to run through a 3-foot length of ⅝-inch plastic hose fitted with a thin metal spout.

Markers to establish the boundaries of each section were set out several days prior to the treatment. The ends of some of the courses were marked with 10- by 10-foot cloth-covered panels attached to piles driven into the bottom mud. The boundary lines along each course were marked by anchored wooden floats carrying flags that were visible for several hundred feet. This elaborate marking system was necessary to keep the boats on the course, especially on hazy days.

Six boats were selected to tow the barges carrying the drums of insecticide. These boats varied in length from 30 to 50 feet and were powered with various sized motors. Each boat was manned by a captain and two or more assistants. The boat speed was set at 5 mph, and this figure was used in calculating the number of drums needed on each area. The six barges were of two types—army surplus LCVP (landing craft, vehicle and personnel) 36 feet long, and heavy plank-type work barges. On the landing craft heavy decks were installed on the aft section to hold two or three drums containing the insecticide. A ramp sloped from the deck to the fore section of each craft. Drums were laid on the ramp and rolled up the deck as needed. The landing craft proved excellent barges for this work and did not require large towing boats, but the plank-type barges were cumbersome and required boats with considerable horsepower to move them.

The two men on the barges set the drums in place and made the necessary adjustments so that the fluid discharged properly. The amount to be dispersed on each section of the lake was determined by calculating the approximate water depth and surface area. One drum was discharging constantly, but over deep water one or more additional drums were set to discharging.

The large arm of the lake was treated with 8,800 gallons of insecticide before nightfall on September 15, 1949. Treatment of the two small arms was finished the following day. The entire operation proceeded according to plan, and the only mishap was the grounding of one of the barges on a submerged rock. Removal of some of the drums, however, released the barge.

It is believed this is one of the largest control operations that has been completed in 1½ days' time. The amount of TDE used was approximately 36,000 pounds, or 18 tons. This would be sufficient to treat about 175,000 acres for mosquito control at the rate of 0.2 pound per acre. Fortunately the concentrate

could be used undiluted. If a 5 per cent solution had been necessary, 70,000 gallons, weighing about 600,000 pounds, would have been required. It is estimated that the boats traveled 1,000 miles in preparing for and dispersing the insecticide.

The cooperation and work of the numerous people involved in the program was excellent. This was an event both the operators and citizens of Lake County had been looking towards for a long time. Most of the people had complete confidence that the gnat problem was solved even before the lake was treated. The community celebrated the event as G-E (gnat eradication) Day (Knipling 1950). There apparently were some doubters, however, since it was rumored wagers were made that Clear Lake gnats would be found the next July! However, after the first few weeks no gnat larvae could be found in Clear Lake by any known means of sampling, and not a single Clear Lake gnat was observed during the summer of 1950.

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IMPORTANT SPECIES OF MOSQUITOES AND CONTROL WORK IN WYOMING

WILLIAM B. OWEN
University of Wyoming

The purpose of this report is to present the results of our studies on the mosquitoes of Wyoming and also to give a summary of mosquito control activities in the state.

For a number of years we have been accumulating information on the species of mosquitoes found in the state, their distribution and the biology of each species. Many phases of the study are still incomplete. Much remains to be learned about the biology of many of the less common species. The total number of species recorded for Wyoming is now 42, as follows:

AEDES: campestris, canadensis cataphylla, cinereus, communis, diantaeus, dorsalis, excrucians, fitchii, flavescens, idahoensis, impiger, increpitus, intrudens, nearcticus, nigromaculis, pionips, pullatus, punctor, riparius, schizopinax, spencerii, sticticus, stimulans, triseriatus, trivittatus, vexans.

ANOPHELES: franciscanus, freeborni, occidentalis, punctipennis.

CULEX: apicalis, pipiens, restuans, salinarius, tarsalis.

CULISETA: alaskaensis, impatiens, incidens, inornata.

MANSONIA: perturbans.

PSOROPHORA: signipennis.

Twelve species were selected as the most important on the basis of numbers of individuals and distribution in the state: *AEDES: campestris, cataphylla, communis, dorsalis, excrucians, fitchii, idahoensis, increpitus, pullatus, vexans; CULEX tarsalis* and *CULISETA inornata.* Many of the other species are troublesome locally. If we were to name the most annoying mosquito to the greatest number of people I think *Aedes dorsalis* would win the honor.

LIFE ZONES. A discussion of the distribution and abundance of mosquitoes in a given area must take into account topography, weather conditions and a

variety of other factors, although I must emphasize that the distribution of mosquitoes is influenced only in a general way by life zones. These zones as they appear in Wyoming, are as follows:

Upper Sonoran Zone. This zone covers that portion of the state at an elevation below approximately 5,000 to 6,000 ft. The lowest elevation is about 3,100 ft. in the northeast corner of the state. Vegetation: Broad leaved trees, cotton wood, juniper, yucca, grasses, saltbush.

Transition Zone. This zone covers approximately one-half of the state (50,000 sq. mi.). The upper limit of the transition zone is at an elevation of approximately 8,500 ft. Vegetation: sagebrush, narrow-leaved trees, cottonwood, grasses, ponderosa pine.

These two zones represent the plains area of the state.

Canadian Zone. This is the area of coniferous forest and has as its upper limits an elevation of about 10,000 ft. Vegetation: Aspen, lodgepole pine, Douglas fir, Engelmann spruce.

Hudsonian Zone. This is the zone of dwarfed forests at high altitudes and has an upper limit at an elevation of 10,500 to 11,000 ft. Vegetation: Dwarfed spruce, Alpine fir, white-barked pine.

Arctic Alpine Zone. This is the area above timberline. The elevation is usually above 10,000 to 11,000 ft. Vegetation: Treeless, except for willows; cinquefoil, red currant, dwarfed raspberry.

HIGH ALTITUDE SPECIES. This group includes those species found in the Arctic Alpine, Hudsonian and most of the Canadian zones. The dominant species are as follows: *Aedes communis, A. cataphylla* (transition upward), *A. pullatus* (transition upward), *A. punctor* (in some areas). Larval habitats of these species are pools fed by the melting of snow. We may describe them as forest pools and pools found in the alpine meadows.

The alpine species are of interest because of the increasing popularity and utilization of recreational areas at high altitudes. These mosquitoes are extremely abundant for a short period in mid-summer.

PLAINS SPECIES. This group of mosquitoes is found over the entire plains areas, their range extending into the Canadian Zone at lower elevations. The dominant species are as follows: *Aedes dorsalis, A. campestris, A. excrucians, A. fitchii, A. idahoensis, A. increpitus, A. vexans, Culex tarsalis, Culiseta inornata.* Larval habitats of these species are flood waters, water in irrigated meadows, temporary ponds filled with rain or melting snow and permanent ponds.

The highest populations of mosquitoes found in the state are in many of the river valleys. Spring floods fill the natural depressions along the streams and at the same time water for irrigation is diverted into the meadows. This irrigation water is permitted to stand on the hay meadows for several weeks. To quote one rancher, "We turn the water on the meadows as soon as possible and keep it there as long as possible." A single large flight of these species appears in the early spring. The peak of abundance is reached in late June and by the middle of August the "mosquito season" is over. A second brood of species like *Aedes dorsalis* is seldom of importance.

Some cities in the state have no trouble with mosquitoes; other cities are located on rivers where conditions are favorable for production of large numbers of mosquitoes.

MOSQUITO CONTROL. Mosquito control has been carried on in Wyoming since 1934. The work is organized on a community basis and financed by the cities and public subscription. We have no state organization or central coordinating agency. Furthermore, Wyoming has no mosquito control law or enabling act which permits the establishment of tax-supported abatement districts. One of the control projects has received limited funds from a local Pest Control District. The law permitting the establishment of Pest Control Districts is not well adapted to mosquito control.

The first mosquito abatement project

was established at Thermopolis in 1934. The State Entomologists planned the work, the local County Extension Agent supervised the project and labor was furnished by the Emergency Relief Administration. My contribution was the identification of a group of mosquitoes collected by the Supervisor.

The second control project was started at Greybull in 1939. The State Entomologists took an active part in planning this project and again I made identifications of the mosquitoes collected in the area. This work was supported in part by WPA and NYA.

Thermopolis and Greybull were the only two cities engaged in mosquito control prior to the war. Within the last few years additional cities have initiated control work. Some of these are limited to mosquitoes while others are considered combined housefly and mosquito control activities.

I have compiled information on mosquito abatement for the season of 1950. The data are not as complete as desired, but are sufficient to give an overall picture of what is being accomplished.

Summary of Control Activities, by Cities

DOUGLAS. The work was financed by the city treasury and supervised by the city sanitarian. Douglas is located on the Platte River. The control area included flood waters and irrigated meadows adjacent to the city. Wettable DDT powder was the insecticide used. The entire city and adjacent areas were treated twice during the summer with an airplane. The number of times the alleys and garbage cans were sprayed with power sprayer were not reported. Cost of the program, $50.00 for insecticide.

SARATOGA. Saratoga is located on the Platte River and attracts many tourists. This project was started in 1950 and was financed by the city treasury and public subscription. The State Department of Public Health provided technical assistance and supervision for the work. Waters serving as a source of mosquitoes were ponds, flood-water and irrigated meadows.

Larvicide used was 3.5 per cent DDT in diesel oil No. 2. This material was applied by hand sprayers and an airplane at bi-weekly intervals during July and August. Cost of the program, $2,000.00 for the season.

EVANSTON. This project was started in 1950. The State Department of Public Health provided technical assistance and supervision. The work was financed by the City Treasury. Evanston is lolated on the Bear River. The mosquito-producing waters were ponds, flood waters and irrigated meadows. The larvicide used was 3.5 per cent DDT in diesel oil No. 2. This material was applied with a hand sprayer and a power sprayer at bi-weekly intervals for a period of 6 weeks.

The cost was $1,000.00 for larvicidal work. Evanston also had a fly control program in which DDT as well as chlordane was used. Exact formulation, timing and rate of application not reported. Cost of fly control given as $257.50.

THERMOPOLIS. This is the oldest control project in the state and is now supervised by the City Sanitarian and the County Extension Agent. Financial support is as follows:

City treasury	$500.00
Public Subscription	125.00
County Pest Control	50.00
	$675.00

Thermopolis is on the Big Horn River. The mosquito-producing waters are a series of ponds adjacent to the river which are flooded each spring. Larvicides used were chlordane and a combination of chlordane and DDT. These agents were dissolved in diesel oil No. 2 and combined with sawdust. The sawdust was saturated with the oil and suspended in the water in burlap bags. The bags were replaced twice during the summer.

Formulations: (1) 100 lbs. sawdust, 2 lbs. chlordane, diesel oil to saturate; (2)

100 lbs. sawdust, 4 lbs. DDT (50 per cent); 1 lb. chlordane, No. 2 diesel oil to saturate. Both formulations gave satisfactory results.

A fly control program was carried on within the city. DDT was the insecticide used. Application was by airplane and a power sprayer. The city was treated three times. Details not reported.

BASIN AND GREYBULL. The abatement programs in these two cities were similar in nature. They were financed by the cities and supervised by the City Sanitarian. The Big Horn River is the source of the mosquito-producing waters. Larval habitats were flood waters, ponds and marshes.

The chemical formulation used was 35 per cent DDT emulsion concentrate diluted with water to a strength of 1.5 per cent. Application was by airplane and power sprayer at the rate of 3½ gallons per acre.

The same formulation was used for fly and mosquito control. Alleys and garbage pails were sprayed weekly. Entire city and adjacent area sprayed monthly for a total of three applications. Combined cost—$1,200.00.

ADULT FLY AND MOSQUITO CONTROL

TORRINGTON. Program was financed by the city. Formulation used was wettable DDT powder and applied with a power sprayer. Alleys and garbage pails sprayed every ten days during the summer. Strength and rate of application not given.

LANDER, RIVERTON AND SHOSHONI. The program was financed by the cities. The entire cities were sprayed with two applications of wettable DDT powder in water. The strength used was apparently 1 per cent applied at the rate of 10 pounds per acre.

(In the summers of 1947 and 1948, larval control was carried on in these areas. The larvicide used was a 2 per cent DDT in No. 2 diesel oil. This program was abandoned because of expense.)

WORLAND. This program has been in progress since 1943 and was financed by the following agencies:

Local residents	$750.00
Jr. Chamber of Com.	500.00
City Treasury	75.00

Supervision was by the county Pest Control Operator. Formulations used were 50 per cent DDT emulsion; .25 per cent–.50 per cent chlordane. Power sprayer was used for alleys, shrubbery and garbage pails, and the entire city was sprayed with an airplane. The control program extends from April 1 to September 15. Total cost, $1,425.00.

AAAS PHILADELPHIA MEETING, DECEMBER 26–31, 1951. The 118th Meeting of the American Association for the Advancement of Science, the annual meeting for 1951, will include programs of all 18 of the Association's sections and about 45 participating societies. Focus of the approximately 225 sessions will be Convention Hall, adjacent to the University of Pennsylvania's School of Medicine and its associated hospitals; there will be some meetings in the downtown hotels, especially the Bellevue-Stratford (headquarters) and the Benjamin Franklin (zoologists).

BRIEF ACCOUNTS OF MOSQUITO CONTROL ACTIVITIES IN DIFFERENT STATES

(Condensed from reports given at the Chicago AMCA meetings, March 5–8, 1951)

Editor's Note: The following papers were presented in their original form at greater length in the Chicago meetings, and rightly occupied a large portion of the program. These reports form one of the most valuable features of the AMCA meetings each year, since the recapitulation of the state activities in an open meeting affords the best possible means of bringing everyone up to date and offers the perfect opportunity for interchange of ideas.

However, in order to have them all in one issue of *Mosquito News* and at the same time have room for other papers, it was necessary to condense them. These condensations were made by Associate Editors Helen Louise Trembley and William E. Bickley. Just as the Association is grateful to the original authors for presenting the reports at length in the meetings, it is also obligated to the above named staff members who spent many hours preparing the final form for readers of *Mosquito News*. An idea of the amount of work involved may be gained from the fact that 5 reports which originally comprised 24 pages of typed manuscript were condensed to 5 pages. It may be pointed out that if serious omissions were made in the condensation process, the omitted material is probably available in the official annual state and local reports of the region covered.

D. L. C.

Activities of the Virginia Mosquito Control Association. By Perry W. Ruth, Technical Advisor, Norfolk City Mosquito Control Commission. Today, in Virginia, more than two-thirds of the half-million persons living in an area of 914 square miles adjacent to Hampton Roads are receiving mosquito control. Almost one-fifth of this area is composed of inland waterways and marshlands, both difficult and expensive to control.

This is a far cry from the days of 1607–08 when malaria is reported to have almost wiped out Jamestown, and those days of 1855 when yellow fever took its toll in the death of one-third the population of Norfolk.

In 1933, the U. S. Public Health Service and the Virginia State Health Department cooperated in the control of disease-carrying mosquitoes and pest mosquitoes; but later, the U. S. Public Health Service confined its efforts to the disease angle, leaving to the state control of pest mosquitoes. In 1940, Virginia authorized the creation of mosquito control commissions. These commissions now operate in southeastern Virginia, and state funds may be allocated up to 25 per cent of the local funds, providing that the state contribution does not exceed $10,000 per annum. So, there can be little doubt that mosquito control in Virginia is established on a strong foundation.

In January, 1951, the Honorable John S. Battle, Governor of Virginia, speaking to members assembled for the 4th annual meeting of the VMCA, referred to the advance of mosquito abatement in the Tidewater area and said: "My memory goes back to the time no one would dream of visiting Virginia Beach after August unless he wanted to go home with the chills and fever of malaria. I'm constrained to believe that the wonderfully improved conditions making this area healthful and malaria-free the year-round are due to the work done in mosquito control."

Mosquito Control in Florida. By V. S. Minnich, Director, E. Volusia County Anti-Mosquito District. There are mosquito control districts in 17 of the 67 counties in Florida; 15 of these controlled counties are coastal and 2, inland. Most of the coastal resort counties, on both east and west coasts, which are affected by

salt marsh mosquitoes have districts which are doing effective abatement work.

The comments of two district supervisors are interesting. One director of operations reported that the annoying smoke blown into Miami from fires in the Everglades had no effect on mosquito density. He said: . . . "neither did the hurricane later in the fall. This was a disappointment to many of the residents, who felt that a strong wind was all that was needed to kill or drive the mosquitoes away. This latter was not an unusual experience, as we have yet to see a hurricane reduce the mosquito density."

Another director wrote: "Two other results of this past summer were that fog applied by the Tifa was most effective on *Aedes taeniorhynchus,* and less effective on *A. sollicitans.* A heavy application of DDT, 5 per cent in oil with the Buffalo Turbine, was most effective on *A. sollicitans.*" A 10 per cent DDT concentrate in No. 2 Distillate was used in the fog machine at the rate of 20 gallons per hour on mobile equipment, moving between 3 mph and 5 mph. For the Turbine, 5 per cent DDT in No. 2 Distillate was used at a concentration of 2 gallons plus per acre.

The success of mosquito control districts is attested to by the constantly increasing amount of tourist business; this is valued at $625,000,000 annually. The annual budget for mosquito abatement in the entire state is $800,000 from local funds plus $350,000 from State funds.

MOSQUITO CONTROL WORK IN NEW JERSEY IN 1950. By M. M. Stallman. During most of the 50 years that organized mosquito control work has been in effect in New Jersey, water management has been used as a basic practice. Recently, large-scale changes brought about by a rapidly growing population have necessitated the use of temporary chemical control measures. These include dispersal of insecticides through aircraft, fog machines, and mist blowers for the control of adult mosquitoes where permanent water management is not complete or practicable.

Construction projects and weather conditions have adversely affected mosquito control in many instances.

A Turnpike and a Parkway, each extending 118 miles, have posed serious problems. The Turnpike traversed miles of tidal marshlands, and the hydraulic and dry fills produced temporary conditions favorable for mosquito breeding. Grading in upland areas resulted in numerous small temporary water traps. The expansion of the Newark Airport resulted in landlocked marsh areas between runways.

Extensive residential construction added its problems, temporary breeding places occurring in foundations and cellars and in many improperly installed septic tanks and cesspools.

Storms along the Atlantic Coast, coinciding with peak tides, inundated all coastal meadows and destroyed or damaged numerous dikes, sluice boxes, tidegates, and drainage ditches.

THE VALUE OF HAVING A STATE ASSOCIATION OF MOSQUITO CONTROL AGENCIES. By Hendrik Van Brederode, Former President, New Jersey Mosquito Extermination Association. New Jersey has pioneered in the methods of mosquito control and in the organization of those activities. In 1902, the State recognized that the only way it could eliminate the mosquito menace was by prevention of breeding. Ten years later, in 1912, the New Jersey Mosquito Act was passed; this set up administrative units, each limited in jurisdiction to county boundaries, and each independent of the other. Coordination was to be effected by the Director of the State Agricultural Experiment Station, who was to supervise the several budgets and lend technical assistance. The State Entomologist has been the representative of the Director in these duties.

On February 20, 1914, the New Jersey Mosquito Extermination Association was formed; and the speaker, Dr. Ralph Hunt,

welcomed the group in the following words: "The objects of such a meeting as this, as I understand it, are that we may come together and hear the statements of the different commissions in regard to how they have done their work, what their problem is, what the cost of the work is, etc., so that we may learn from each other those practical points which come only from the varied experience of many men working along kindred lines. It is always true that any problem may be solved in many different ways. We are beyond the point where we feel that there is only one way by which to attain a given object. We feel that one commission may adopt methods differing in nature and cost from those of another commission, yet that its results may be equally good with those of the one following entirely different lines. It is with the object of instructing one another that we are met together in this convention.

"Again, another thing which brings us here is to educate, if we may, the public; to show them that we are in earnest in this work; that we believe in it; to demonstrate to them in what ways we expect to bring this object about; and to produce the reports from the different commissions showing what work has been accomplished."

The original conception of a State Association has been fulfilled and its value demonstrated in New Jersey. There is cooperation between the state and the county commissions; and there is cooperation among the several commissions. The reports of research carried on by the scholars in the laboratories and the experiences and experiments of the men in the field are presented at the annual meetings of the State Association; and they are preserved in the *Proceedings* as a reservoir of learning that will endure.

Mosquito Control in California. By Jack H. Kimball, President, California Mosquito Control Association Manager, Orange County Mosquito Abatement District. California, a state over 1,000 miles long and 200 miles wide, has a mosquito problem of vast proportions and many angles. The size and complexity of the problem are indicated by the total expenditure of $2,100,000 for mosquito abatement during the 1951 fiscal year.

Historically, mosquito control goes back as far as 1905, when salt marsh mosquito control was under way in the San Francisco Bay area; it was not until 1915, however, that legislation was enacted permitting the formation of Mosquito Abatement Districts. There are now 48 active districts, with a total area of 20,800 square miles, and an annual budget from local funds of more than $1,700,000.

The Bureau of Vector Control was organized shortly after the close of World War II, to administer, in addition to its other services, a yearly fund of $400,000 provided by the State for allocation to local agencies where endemic virus encephalitis and/or malaria threatened.

Two especially important problems (discussed in detail by other speakers) are those posed by the Central Valley Water Development Plan, which through the rapid expansion of the already numerous irrigated areas, has increased the opportunities for mosquito breeding; and by the rice fields of the Sacramento Valley, which present unusual and difficult breeding conditions.

A Brief Mosquito Survey of Pacific Islands. By Robert T. Mikuni, Sanitarian, Chief Supervisor, Bureau of Mosquito Control, Department of Health, Honolulu, T. H. In cooperation with the Civil Aeronautics Administration, inspection and clean-up work on Pacific islands where American airports are maintained was initiated in 1949 as a means of preventing the spread of exotic species to Hawaii or the mainland.

The fact that *Anopheles subpictus* was found on Guam for the first time by Reeves in 1948 illustrates the point that new species are introduced into island areas. Japanese B encephalitis also has been reported from Guam; and a potential vector, *Culex quinquefasciatus,* was

found to be abundant in 1949. *Aedes pandani* is considered the worst pest mosquito on Guam, and it is hoped that it will not be introduced into Hawaii.

In December 1949, *C. quinquefasciatus* constituted a nuisance on Wake Island. Subsequent DDT spraying effected control, and it should be possible to eradicate all mosquitoes.

Midway is free of mosquitoes; there are few possible breeding places.

Palmyra Island has a rainfall of about 150 inches per year, and there are many potential breeding places. *C. quinquefasciatus* was evidently introduced during the last war. Some DDT spraying was carried out in 1949. There are fewer than 80 people on the island.

Canton Island, an important stopover for planes from the South Pacific covers about six square miles and has a population of about 300. Apparently *Culex* mosquitoes, introduced during the last war, have been eradicated.

Hawaii serves as a mosquito filter for planes that fly across the Pacific to the west coast of the United States.

BRIEF REPORT ON MOSQUITO CONTROL ACTIVITIES IN NASSAU COUNTY, NEW YORK. After existing for thirty-one years, the Nassau County Mosquito Extermination Commission was superseded in 1947 by a division of the Nassau County Department of Public Works. This change has resulted in closer cooperation, better planning, and altogether improved mosquito control activities.

Emphasis has been placed on reconditioning salt marsh drainage ditches on the south shore, especially the Jones Beach section.

In addition to checking more than 290 miles of fresh water streams and many ponds, swamps, pools and other wet areas, more than 20,000 acres of salt marsh must be patrolled. Five million feet of drainage ditches are maintained, and 25,000 catch basins or street drains are treated every three weeks from April to October. Other problems consist of artificial recharge basins and drainage channels for discharge of storm water.

A new technicolor movie on County Mosquito Control activities is being assembled during 1951.

MOSQUITO CONTROL IN PENNSYLVANIA. By Russell W. Gies, S.E., Director, Delaware County Mosquito Extermination Commission. Since World War I, Philadelphia has maintained a mosquito control program. As control activities were intensified during World War II in the Philadelphia area, other communities followed the lead of Delaware County in initiating organized control. There are 150 communities in more than 20 counties spending a total of $150,000 for mosquito control. The work is in cooperation with the Bureau of Sanitary Engineering of the State Department of Health.

The problems vary in different parts of the state. Some examples are polluted water and extensive marshland in and around Philadelphia, woodland breeding in resort areas, holes and pools peculiar to mining regions, and house mosquitoes in towns and cities. Over one million people are protected through the activities of the various mosquito control organizations.

MOSQUITO CONTROL WORK IN MARYLAND IN 1950. By Wm. E. Bickley and George S. Langford, College Park, Maryland. The Maryland State Board of Agriculture through the State Entomologist or his agents is legally authorized to cooperate with any political unit of the state carrying out anti-mosquito work. Although no funds have been appropriated by the state specifically for mosquito control, the State Entomologist and the Extension Service of the University of Maryland in recent years have done extensive educational work and have cooperated with several counties, cities, towns and communities in mosquito control activities. Much of this work has been of an experimental nature, and the emphasis has been placed on demonstrating to the local people some satisfactory and economical means of mosquito abatement. Largely as a result of

this type of demonstration work, some communities have purchased equipment and now carry out their own mosquito abatement work.

In 1950, eight towns operated their own programs, and cooperative projects on an experimental basis were carried out in eight towns by the Department of Entomology. Excellent results were achieved with a mist-blower using DDT emulsion.

ARTICLES

TOXICITY OF SEVERAL ORGANIC INSECTICIDES TO ANOPHELINE LARVAE[1]

JOHN C. KELLER, A. N. DAVIS, and C. I. MOONEY
U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine

During the last 5 years several thousand organic compounds have been screened at the Orlando, Fla., laboratory for toxicity to larvae of *Anopheles quadrimaculatus* Say. A great many of these compounds showed some degree of toxicity to this species, but only a few were sufficiently promising to warrant field testing as larvicides. Most of the better compounds have been available for several years and many mosquito control workers have tested them against various species. A review of the published information on various new compounds, together with some original data, was published by Travis and McDuffie (1950). Additional tests have now been run with most of the better materials against the larvae of *A. quadrimaculatus* in the laboratory and against this species and *A. crucians* Wied in the field. Data from tests conducted in 1950 and 1951 are presented in this paper.

Laboratory Tests

Screening tests were conducted in the laboratory against fourth-instar *Anopheles quadrimaculatus*. The toxicants were first dissolved in acetone and then introduced into beakers of distilled water in the amounts necessary to give a range of concentrations. Distilled water was used to avoid the effects of suspended matter and dissolved chemicals that occur in other types of water. From 4 to 10 replications of 2 tests of 25 larvae each were made at a range of concentrations with each chemical. DDT was included as a standard of comparison in each series of tests and

[1] This work was conducted under funds allotted by the Department of the Army to the Bureau of Entomology and Plant Quarantine.

mortalities were observed after 24 and 48 hours.

As shown in Table 1, parathion was the most toxic compound, closely followed by dieldrin, and both materials were considerably more effective than DDT. Toxaphene and chlordane were slightly less toxic than DDT. Dilan [1] and its components were the least toxic of the materials tested.

Field Tests

Field tests of the same compounds used in the laboratory tests were conducted on small plots 200 to 1,000 square feet in size. The plots were located in drainage ditches and roadside borrow pits that were generally choked with hyacinths, water lilies, and grass. The larval population consisted of all stages of *Anopheles crucians* and *A. quadrimaculatus,* with the former predominating. Larval populations were determined by dipping counts and averaged from 1.3 to 11.0 per dip in the plots before treatment. The effectiveness of the various dosages and materials was based on the reduction in larval counts 24 hours after treatment.

Most of the insecticides were tested at several dosages, both as oil solutions and emulsions. All treatments were applied with a small hand atomizer, which produced a very fine particle size, and at a standard rate of 5 pints per acre. Different dosages were obtained by varying the concentration of the insecticides in the sprays. From 3 to 10 replications were made with each dosage of insecticide. Results of the tests are summarized in Table 2.

Dieldrin was the most toxic of all the compounds tested, both as an oil solution and as an emulsion. It was slightly more effective than heptachlor, DDT, and parathion, which were about equal, and all were much more effective than toxaphene, aldrin, chlordane, or lindane. As in the laboratory tests, Dilan and its components were the least effective of the compounds tested. Fuel oil alone on check plots caused considerable mortality in some cases, but on the whole was relatively ineffective at the rate at which it was applied (5 pints per acre).

In comparative tests with four materials—dieldrin, DDT, lindane, and toxaphene—all were more effective in emulsions than in oil solutions (Table 3). The difference was slight with dieldrin but rather marked with DDT, lindane, and toxaphene.

A comparison of the results of the laboratory and field tests showed that heptachlor was considerably more toxic in the field than in the laboratory. With parathion, the reverse was indicated. The remaining compounds showed about the same relative toxicity in the field as in the laboratory.

In 1946 other workers at the Orlando laboratory (unpublished report [2]) conducted similar small-plot tests with DDT, chlordane, TDE, toxaphene, benzene hexachloride (12 per cent gamma isomer), and methoxychlor, and the results are briefly summarized below. The materials were dissolved in No. 2 fuel oil and applied as mist sprays with a paint sprayer. All solutions were applied at the rate of 0.6 gallon per acre at concentrations of 0.63 and 1.25 per cent, to give dosages of 0.05 and 0.1 pound of toxicant per acre.

DDT was the most effective and methoxychlor the least effective material. The average per cent reductions of the larvae after 24 hours from five replications of each treatment were as follows:

	Dosage (Pound per acre)	
	0.05	0.10
DDT	89	99
Chlordane	65	95
TDE	59	86
Toxaphene	56	88
Benzene hexachloride (12 per cent gamma isomer)	66	56
Methoxychlor	34	48

[1] A 1:2 mixture of 1,1,bis-(*p*-chlorophenyl)-2-nitropropane and 1,1-bis(*p*-chlorophenyl)-2-nitrobutane.

[2] Raun, E. S., Gilbert, I. H., and Deonier, C. C. Field tests of several insecticides as anopheline larvicides.

Table 1. Comparative toxicity of 11 organic compounds in acetone suspensions to fourth-instar larvae of *Anopheles quadrimaculatus*. (Averages of 4 to 10 replications.)

Material	Percent mortality in 48 hours at indicated concentration in p.p.m.									LC-50 [1] (p.p.m.)
	.1	.05	0.025	0.01	.005	0.0025	0.001	.0005	0.00025	
Parathion	...	...	...	...	...	100	79	28	12	0.0006
Dieldrin	...	...	...	...	100	91	62	...	...	0.0008
DDT	...	...	...	100	94	48	24	...	...	.0021
Toxaphene	...	...	100	98	80	43	...	...	...	.0027
Chlordane	...	...	...	100	98	54	...	...	...	.0028
Aldrin	...	...	100	82	67	34	...	...	...	.004
Heptachlor	...	...	100	58	22	4	...	...	...	.008
Lindane	...	100	58	28	13	...	...	...	...	.013
1,1-Bis(*p*-chlorophenyl)-2-nitropropane	100	93	38	6	...	...	...	...	...	.020
Dilan	97	77	39	12	...	...	...	...	...	.027
1,1-Bis(*p*-chlorophenyl)-2-nitrobutane	96	52	26	6	...	...	...	...	...	.036

[1] Determined from regression lines fitted to log-probability transformations, without use of weighting coefficients. For dieldrin the 50% point was obtained by extrapolation.

TABLE 2.—Results of field tests with emulsions and oil solutions of various larvicides against anopheline larvae.

Material	Percent mortality in 24 hours at indicated dosages (pound per acre)						
	0.1	0.05	0.025	0.0125	0.006	0.003	0.0015
Emulsions							
Dieldrin	...	...	...	98	98	98	96
Heptachlor	...	...	...	98	90	80	64
DDT	...	...	100	96	87	81	59
Toxaphene	...	...	...	93	84	82	...
Aldrin	...	...	99	88	83	86	53
Lindane	...	...	90	84	80	71	...
1,1-Bis(*p*-chlorophenyl)-2-nitropropane	100	90	93	82	72	71	...
1,1-Bis(*p*-chlorophenyl)-2-nitrobutane	93	88	88	77	73	65	39
Dilan	91	85	84	73	75	64	...
Oil Solutions							
Dieldrin	...	100	99	98	92	87	76
Parathion	...	...	...	92	79	67	66
DDT	...	98	96	95	79	57	56
Chlordane	...	93	88	64	...	...	...
Lindane	...	90	87	65	...	...	...
Toxaphene	...	86	63	62	...	...	...

TABLE 3.—Comparative toxicity of emulsions and oil solutions of dieldrin, DDT, lindane, and toxaphene to anopheline larvae in field tests.

Type of treatment	Percent mortality in 24 hours at indicated dosages (pound per acre)				
	0.025	0.0125	0.006	0.003	0.0015
Dieldrin					
Emulsion	..	98	98	98	96
Oil solution	99	98	92	87	76
DDT					
Emulsion	..	100	96	87	81
Oil solution	96	95	79	57	56
Lindane					
Emulsion	90	84	80	71	..
Oil solution	87	65	..	..	..
Toxaphene					
Emulsion	..	93	84	82	..
Oil solution	86	63	62	..	..

Fuel oil alone at dosages of 0.6 to 2.9 gallons per acre caused reductions of 46 to 87 per cent in 24 hours.

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SEXUAL DIMORPHISM IN MOSQUITO PUPAE[1]

HERBERT H. MOOREFIELD
University of Illinois

Structural difference in the sexes of mosquito pupae is so obvious that it seems unlikely this fact should have escaped the attention of so many investigators. However, a review of the literature has revealed no indication of general cognizance of sexual dimorphism in this stage of the mosquito's life history.

Cantrell (1939) pointed out that there is a significant difference in the size of pupae of *Aedes aegypti* (L.) which will permit separation of the sexes of this species prior to emergence. Measurements made on *A. triseriatus* (Say) also demonstrated a difference in range of size, but there was an overlapping in size of the small female pupae and the large males. *A. vexans* (Meig.) was not separable on a size criterion as the range was almost identical in both sexes.

Penn (1949) in his recent papers on mosquito pupae, has illustrated males of some species and females of others, all sexed and correctly labeled, but he has neither mentioned the intraspecific differences nor given the dimorphic patterns of any single species.

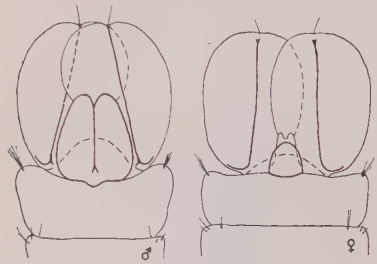
Although there were many discrepancies in earlier works, later papers treating the morphology of mosquito pupae (Edwards 1941, Knight and Chamberlain 1948, Penn 1949) are in accord as to the segmentation of the pupal abdomen. Ten abdominal segments are now considered to be present. The ninth segment is fused immovably to the tergum of the eighth segment and lies dorsad of the paddles (on plate I, segment nine is represented by a broken line). Ventrad of the paddles, attached to the sternite of the eighth is the tenth abdominal segment, which has also been termed the genital pouch. It is through the examination of this tenth or genital segment that the sex of the future adult mosquito can be determined prior to eclosion.

The terminal segment of the male pupa, in all of the species studied, was shield-shaped and bifurcate on the distal end. The female genital segment showed much more interspecific variation and was generally more broadly ovate in form. Although the majority of taxonomists working on the classification of mosquito pupae have almost exclusively used the trumpets, paddles and chaetotaxy for identification, the genital segment also appears to possess good, valid, taxonomic characters which should not be overlooked.

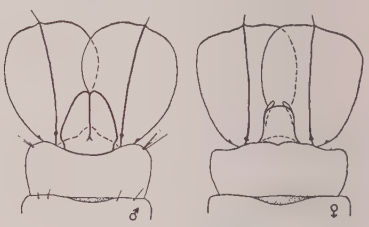
In the course of this study, eight common species of mosquitoes, representative of five different genera, have been examined and reared. These were *Aedes stimulans* (Walk.), *A. trivittatus* (Coq.), *A. vexans* (Meig.), *Anopheles punctipennis* (Say), *Culex apicalis* Adams, *C. restuans* Theob., *Culiseta inornata* (Will.) and *Psorophora ferox* (Humb.). In each case there was sufficient morphological difference to permit sexual separation of the pupae before emergence, and the results were all verified by re-examination of the adults. A single exuvium of a male *Megarhinus septentrionalis* D. & K. exhibited features analogous to males of the other species, and dimorphic characters are expected to parallel those depicted, but as there were no female specimens at hand for comparison this species has been omitted from the plate.

A simple technique was employed for separating the living pupae. By cutting off the tapered portion of a medicine dropper and fire polishing the end, a convenient, short, transfer pipette can be made which will take up only a few milliliters of water with the pupa. In a short time, the pupa will come to rest in the meniscus

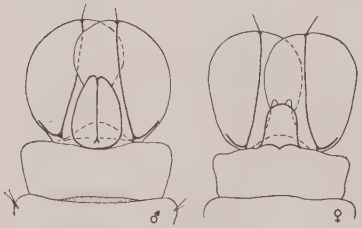
[1] Contribution from the Entomological Laboratories of the University of Illinois.



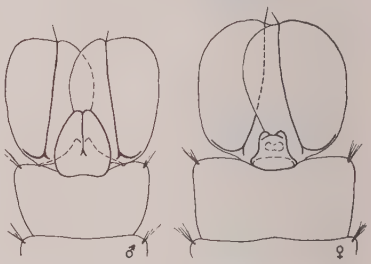
AEDES STIMULANS (WALK.)



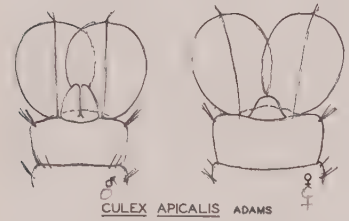
AEDES TRIVITTATUS (COQ.)



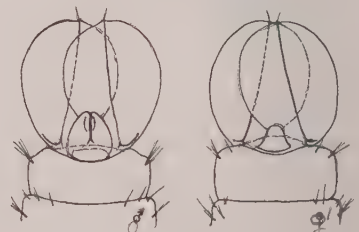
AEDES VEXANS (MEIG.)



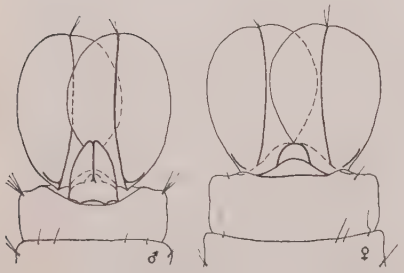
ANOPHELES PUNCTIPENNIS (SAY)



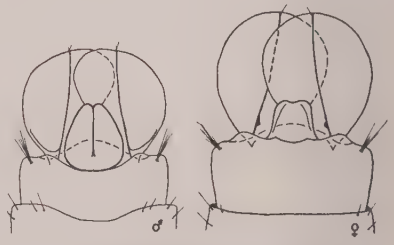
CULEX APICALIS ADAMS



CULEX RESTUANS THEOB.



CULISETA INORNATA (WILL.)



PSOROPHORA FEROX (HUMB.)

DIMORPHISM IN REPRESENTATIVE SPECIES OF MOSQUITO PUPAE

(DRAWN FROM VENTRAL ASPECT)

at either the top or bottom of the water column. The surface tension on the trumpets together with the body contact on the walls of the pipette will keep the individual immobile. If reasonable care is exercised and the pupa is not jolted or jarred, the pipette may be turned on its side or in any other position which will offer an examination of the genital segment while the pupa remains *in situ*. This can best be accomplished by means of a binocular dissecting microscope, but a good hand lens will serve equally well after one becomes familiar with the patterns of the species with which he is working. The dimorphic characters can also be recognized in a profile view, and through such aids as comparing the relative length of the tenth segment with that of the ninth and the paddles, one can soon become quite proficient in sexing mosquitoes in the pupal stage.

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OBITUARY

DR. HARRY MARTINDALE SPEECHLY

Dr. Harry Martindale Speechly, the son of the first missionary Bishop of the Anglican Church in Travancore and Cochin, India, was born in Cochin in 1866. He received his primary education at Monkton Combe School in Bath, England, attended Cambridge University, and took his medical studies at London Hospital. His medical degrees were M.R.C.S. (England), and F.R.C.P. (London). The University of Manitoba also conferred on him the honorary LL.D.

Dr. Speechly came to Canada in 1901, settling at Pilot Mound, Manitoba. He was Coroner at Pilot Mound from 1906 to 1916, and Provincial Coroner from 1920 to 1942. During the first World War he served as an army medical officer at Fleet, England, and in the second he was assistant medical officer at King Edward Hospital in Winnipeg.

Dr. Speechly died at Winnipeg on March 17, 1951. He is survived by his wife, Mary; his sons, William of Winnipeg and Leslie G. of Montreal; and by a daughter, Mrs. E. J. Stansfield of Winnipeg.

His chief secular interest was the Greater Winnipeg Mosquito Campaign, of which he served as President and Chairman since its organization in 1926. In 1950 he was elected the first regional Director from Canada in the American Mosquito Control Association.

His was a vibrant and arresting personality indeed, keenly interested in all about him, and with a unique and frequently pungent way of expressing his ideas. Those who had the pleasure of seeing him at technical and professional meetings greatly enjoyed his forthright personality and good practical sense.—Harold F. Gray.

NEWS AND NOTES

THE FOLLOWING LETTER to Mr. Mulhern, because of its interest to AMCA members, is published in its entirety.

"Turoa"
Raratonga
Cook Islands
24th April 1951

Mr. Thomas D. Mulhern, Secretary
American Mosquito Control Association
334 Rowell Building
Fresno, California

Dear Sir:

I have been given your name by Captain R. W. Babione, MC, USN, as one who could give me some information on the latest efforts in mosquito control.

For the last twenty-five years I have taken an active interest in the control of mosquitoes in this part of the Pacific, and during the last war when I served in the N.Z. Air Force, had the pleasure of meeting many American officers with kindred interest.

Since the war it has been more difficult to get any up to date information, and I am informed that there is a publication "Mosquito News" published by your Association. I would be glad to know the cost of subscription.

As you are no doubt aware our principal disease carried by mosquitoes in this part of Polynesia is filariasis, the vector of which is in this section *A. scutellaris pseudoscutellaris,* but with a fortnightly call of aircraft from Fiji, there is always the danger of introducing yellow fever, and dengue, as we have *A. stegomyia aegypti.*

My interest is that of a student, and I have for years devoted time to developing a type of larvivorous fish that would act as a check in the swamps.

The principal difficulty is that storm water carries off the fish and dry periods kill them, however, by renewing the supply frequently they have a definite value, especially if used with the insect *Anisops cleopatra,* which has the power of short flight and can fly from pool to pool.

In some of the islands of New Britain, there is a small Ceratopogonine that appears to suck from the adult mosquito.

Should any of your Association be in this part of the Pacific I would be glad to meet them, and give them some of my fish for further experiment.

Yours faithfully,
(Capt.) J. D. Campbell

THE INTERNATIONAL RESEARCH CENTRE FOR CHEMICAL MICROBIOLOGY was formally opened in Rome on June 25. The Centre, directed by Professor E. B. Chain, F.R.S., is attached to the *Istituto Superiore di Sanità,* the chief center for medical research and drug control of the Italian Government. Its Director is Professor Domenico Marotta. The Centre, which is recognized by WHO as an international Centre, will provide international research and training facilities in antibiotics. It will meet the need felt by many countries which lack facilities for basic research on antibiotics, particularly as regards problems of production. Its new laboratories contain large-scale pilot plant facilities for the production in substantial amounts of substances of microbiological origin and biochemical interest for research purposes.

From Bill Perry:

The following short note may be of interest to you for reproduction in MOSQUITO NEWS in your "News and Notes." As usual, the greatest burden of work still rests in physiology and so forth with little chance to keep up the medical entomologic aspects and problems in tropical medicine. This note I am including is of importance, however, because it represents a shift in emphasis such as many of us predicted would happen during the control operations in the Pacific. For lack of a better title I might list it "Effect of Malaria Control on Immunity":

"During a recent meeting of the Royal Entomological Society of London the problem of immunity and malaria control was discussed following the presentation of a color film on the mosquito eradication campaign in Cyprus.

"Emphasis was placed on the danger of a recurrent epidemic in malarious areas when natural immunity was reduced in an indigenous population through attempted complete mosquito eradication in endemic areas.

"Experience on Sardinia suggested that children ceased to possess a natural immunity to malaria through such control measures and that epidemics may be expected if adequate preventive measures are not continued.

"The results of such campaigns on Sardinia, Cyprus and Greece, leaves one to speculate on the current incidence of disease in native populations on many of the South and Southwest Pacific Islands where control measures, since the withdrawal of military troops from these areas, were stopped completely after 2–4 years of anopheline eradication.

"In addition, Professor F. J. C. Cambournac, W.H.O. expert on malaria, and one of the principal participants in the Malaria Congress which met at Kampala (Uganda), made a seven months' tour of Equatorial Africa and presented an account of the general survey of malaria in this area. The problem of hyperendemic malaria and immunity was one of the main questions on which the conference had to take a decision. In brief, however, they indicated, too, that adequate controls should be maintained to reduce the risk of re-infecting populations which, as a

result of control operations either complete or partial, have lost their immunity to malaria."

I talked with Dr. Bishopp yesterday and, unfortunately, because of his tight schedule I was not able to have lunch with him during his stay in London. I am looking forward to meeting him, however, in Amsterdam when we both will be attending the sessions on medical entomology during the international congress.

My very best regards.

Sincerely yours,
William J. Perry

DR. RICHARD H. DAGGY of the Arabian American Oil Company, Dhahran, Saudi Arabia, has written as follows:

"As for your 'News and Notes' requests, I suppose I should account for myself after 4 years in Arabia—especially since I thoroughly enjoy reading accounts of activities of friends and professional acquaintances with each new issue of MOSQUITO NEWS. Although more and more of my time is taken up with administration of our Preventive Medicine Division, I'm still very much interested in the mosquito and malaria control problems here in Saudi Arabia and feel that others may be interested and perhaps surprised at a mosquito-malaria problem in a predominately desert country.

"One of our largest projects has been that of DDT residual spraying as a malaria control measure in nearby oasis towns and villages. Malaria has always been a most important health problem in irrigated lands in Arabian oases. Before we began our DDT program, more than 2,000 of our 10,000 Arab employees reported to our hospitals and clinics with malaria in the single year of 1947. After two successive years of DDT control, less than 50 reported in the same period of time. Checks on children in the villages disclosed an average of over 80% parasite infections before treatment. After 3 annual applications this has been reduced to 2% in some of our test villages—another excellent illustration of the success of DDT house spraying in malaria control where a domestic species such as our *Anopheles stephensi* is concerned.

"At present we are planning our next annual application for September 1951. Over 450,000 pounds of 75% DDT wettable powder will be used in the Qatif oasis on the coast, in the Hofuf oasis farther inland, in the Al Kharj area, and in Riyadh in the interior. Much of our efforts are aimed toward training Saudi Arabs in residual spray techniques. We've found that 75% wettable DDT and wheelbarrow sprayers are most successful under our conditions. We are looking forward to even better results in cases prevented and a further reduction in parasite indices in children after our repeat surveys this coming November and December.

"Another interesting project still underway is an *Anopheles* eradication attempt in the isolated Jabrin oasis some 300 miles inland from Dhahran on the edge of the Empty Quarter. Here is an abandoned oasis with evidences of past settlements, some of great age, and more recent evidence of attempted agricultural colonization. From all historical accounts and current history, malaria has been the deciding factor in failure of agricultural development in the past.

"Our investigations showed *Anopheles sergenti* breeding in about 800 wells and small pools in the area. Using Lovett's DDT-impregnated briquette technique reviewed in MOSQUITO NEWS *8*(3):126, we planned a series of well treatments designed to knock out all breeding places during the summer and fall months of 1951. Our hope is that adults will not be able to survive the hot weather of Saudi Arabia for more than a few months—and that with all breeding places residually treated, the species will be eradicated from the area. With *sergenti* a relatively weak flyer and the oasis remote from other breeding areas, we hope *sergenti* will not be able to re-establish itself.

"It will be an interesting project to watch since most of us have been intrigued by eradication possibilities—even though we realize that Jabrin is not quite another Sardinia or Cyprus.

"In conclusion let me issue an invitation to old friends and other MOSQUITO NEWS acquaintances to stop by Dhahran and visit us if any of them are passing through this part of the world. We are sure you will find some unusual mosquito and malaria problems of interest and we will be most happy to show them to you.

Sincerely,
Richard H. Daggy
Preventive Medicine Supervisor"

DR. F. C. BISHOPP was among those attending the Ninth International Congress of Entomology held in Amsterdam, the Netherlands, August 17 to 24.

RICHARD F. PETERS is now Chief of the Bureau of Vector Control, California State Department of Public Health. He succeeds Arve H. Dahl who recently took a position with the Office of Civilian Defense in San Francisco.

FROM THE OFFICE OF THE SURGEON GENERAL, U. S. Army, Lt. Col. F. W. Whittemore, Jr., has supplied the following information about AMCA members: Stanley J. Carpenter has been given the permanent rank of colonel and is now on duty in the Sixth Army Area Laboratory, Fort Baker, California. Lt. Col. F. S. Blanton recently received his Ph.D. at Cornell and is now in Panama where he succeeded Col. Carpenter at Fort Clayton, Canal Zone. Captain Gordon Field is working in the Office of the Surgeon General in

Washington. Lt. Frank Favorite is now Chief of the Entomology Branch, Third Army Medical Laboratory, Fort McPherson, Georgia.

CDC TECHNICAL DEVELOPMENT SERVICES reports that in small land-locked ponds where hazards to fish and other wildlife do not have to be considered, Dieldrin emulsion at the rate of one pound per acre gave effective control of mosquito larvae for one to two years—from the CDC Bulletin 10:(4), p. 22, Apr. 1951.

Obviously such a potent larvicide should be used with extreme caution in areas where attention must be given to wildlife.

MOSQUITO TRAPS may be purchased from Foster and Morrison, 120 Kentucky St., Bakersfield, California, as well as from Hausheer's Machine Works, Bayville, N. J. If other manufacturers will advise us of their existence, we shall give them a little free advertising too.

ENTOMA, a directory of insect and plant pest control, is expected to come from the press in early December.

AN EXCERPT FROM A RECENT LETTER TO TOMMY MULHERN is reproduced with Dr. Matheson's permission:

"I was very pleased to get your letter of Feb. 10th and to learn that you are happy and content in that famous state of California. Mosquitoes seem to be booming and with more and more development of irrigation farming can the people expect anything else but that the mosquitoes should take advantage of this wonderful opportunity and multiply to their fullest extent under such a wonderful climate? Furthermore there is no way to exclude wandering mosquitoes from other parts of the country, quarantines are probably not *very* effective. *Aedes nigromaculis* is a visitor and I am waiting to hear that our old friend *Anopheles quadrimaculatus* has at last reached the golden state. What a wonderful time it should have? What I cannot understand is its failure to reach California before this.

"Life moves on as usual here in the East. Spring is coming slowly but I will not be able to run about the hills, marshes, lakes and streams to seek my friends, the mosquitoes, as in previous years. However I hope to follow a few of my friends and learn a few new things. I am back to work about half the time now and still have an office in Comstock Hall where I enjoy reading what my friends are doing and all I can do is to wish them well. Perhaps I am a pessimist but I do not think we shall be able to exterminate many of our blood-sucking friends. . . .

"With all good wishes and best of luck,

Sincerely yours,

Robert Matheson."

MR. RUFUS VINCENT has returned to the mainland after a long tour of duty on the Island of Guam. He is now working in the office of the Chief of Engineers, U. S. Army, Washington, D. C.

Aedes aegypti CAMPAIGN IN THE AMERICAS. The number of successful campaigns that have eradicated insect vectors can be counted on the fingers of one hand. It is interesting, however, to note the success that has attended the efforts in eradicating *aegypti*. This mosquito, because of its domestic habits and short flight range, has already been eradicated from many localities by collaborative campaigns between Latin American countries and the Pan American Sanitary Bureau, Regional Office for the World Health Organization. Dr. Soper states, "It is the first time in the history of the world that a continent is collaborating on a program for the solution of a public health program and the eradication of a disease vector on a continental basis."—*Tropical Medicine News.*

ACCORDING TO TROPICAL MEDICINE NEWS the World Health Organization has been asked for help in malaria control by King Ibn Saud so that additional agricultural areas in Saudi Arabia can be settled.

A SERIOUS SHORTAGE OF DDT is reported by the Pan American Sanitary Bureau in the June number of Tropical Medicine News. The United States produces about 75 per cent of the world supply. There has been an increase in allocations for defense needs and a shift of some of our benzene production to manufacture synthetic rubber. Several countries in South America and Asia have been affected by the shortage.

THE STEM, PHS MISSION to Thailand to assist the Thai government in the expansion of its malaria control program has found energetic and enthusiastic cooperation from the malaria workers of Thailand. Even remote villages are reached by transporting DDT drums over difficult trails on bullock carts, and survey men often walk 10 to 20 kilometers to reach off-the-road settlements.

Participating in the program are Dr. M. E. Griffith, Entomologist, PHS, STEM to Thailand; Dr. Tanticharen, in charge of the station at Bhrabhudabat; Dr. Erval R. Coffey, M.D., PHS, Chief of PHS Mission; and Dr. Ayurikit, Chief, Div. Malaria, Thailand Dept. Health.—D. C. and E. Thurman, c/o U.S. STEM, U.S.P.H.S., Chiengmai, Thailand; contributed by H. L. T.

DR. LOUIS L. WILLIAMS, Chief, Division of International Health, U. S. Public Health Service,

has, according to him, become strictly a "homebody." We wonder, however, just how long this quiet existence will last. He is most enthusiastic about the work being done by DDT young men around the world. He emphasized, too, for the AMCA members, that in practically every country where Public Health Service directs projects for ECA and the Point 4 Program that malaria control is one of the important undertakings.—H. L. I.

Reviews and Abstracts has acquired assistants in 4 foreign countries:

Brazil, Dr. Fernando de Bustamante, Rua Aristides Espínola 11, Apt. 3—Leblon, Rio de Janeiro, D. F., Brazil;

Thailand (Siam), Ernestine and Deed C. Thurman, Jr., U.S. STEM, U. S. Public Health Service, Chiengmai, Thailand.

India, Dr. Rajendar Pal, Malaria Institute of India, 22 Alipore Road, Delhi, India.

These members have graciously consented to screen and abstract the literature from their part of the world and so make available to the AMCA much information which otherwise might remain obscure.—H. L. I.

"Insect Control by Chemicals" is the title of a book just published by John Wiley and Sons. The author is Dr. A. W. A. Brown of the University of Western Ontario. A review will appear in the December Mosquito News.

News from Virginia. The fifth annual meeting of the Virginia Mosquito Control Association will be held at the Chamberlin Hotel, Old Point Comfort, on Jan. 7, 1952. This year's officers are as follows:

President—Jonathan S. Gibson, Warwick County
Vice President—Dr. L. H. Denny, Portsmouth
Second Vice Pres.—V. D. McManus, Williamsburg
Third Vice-Pres.—J. W. Dennis, Jr., Norfolk
Secretary Treasurer—Rowland E. Dorer, Norfolk

Two new mosquito control districts have been established in York County. The Hampton Roads area is having the worst infestation of salt marsh mosquitoes in many years.

There was widespread publicity concerning an outbreak of what was at first thought to be encephalitis in Richmond in midsummer. The so-called epidemic died out very rapidly, and it is now known that the disease was meningitis.

Dr. T. B. Magath, writing in the June Tropical Medicine News, states that 16,000 servicemen who served in Pacific areas were diagnosed as being infected with filariasis. It is highly improbable that this figure is a valid one; in only a handful of cases were microfilariae demonstrated in the blood. Adult worms were observed in sections made of lymph nodes in a small group. A pilot study of the present status of these veterans has shown that almost none of the patients now exhibits any difficulty which can be definitely said to be caused by the infection.

The Question of Complaints as a means of measuring the success of a mosquito control program has been discussed in two recent issues of Mosquito Buzz, the news-sheet of the California Association. An engineer has commented that in sanitation work he has found few complaints in areas where conditions are at their worst. People in rat infested areas expect to see rats and do not complain about them. Yet people in relatively rat free areas seldom see a rat and do complain when they see one. He believes that complaints are almost totally unreliable as an index of environmental sanitation conditions.

A Mosquito Abatement District Manager believes that properly interpreted, complaints give almost as good an index of mosquitoes as light traps, leg counts or what have you. When a complaint is answered all possible information is gathered, and survey records are checked so that the complaint can be classified largely on the basis of the type of mosquito. In this particular district *Aedes nigromaculis* is the cause of a great many complaints, and it is felt that reduction in the number of complaints from this cause are without doubt due to control efforts.

It is probably true that the proportion of valid complaints is relatively high in areas where control work is successful. It has been noticed by many workers that in a new control zone a very small number of mosquitoes will cause a large number of complaints after the area has been almost free of mosquitoes for only one or two seasons. People have forgotten how bad the mosquitoes were before control measures were initiated. They have become spoiled.

Recently it was found in a Maryland zone that a number of complaints could be easily correlated with an increase in mosquito density. In this case the complaints were a help in forcing a more thorough check on the cause of the increase in population (a faulty formulation of insecticide).

But whatever their value as an index of good control or regardless of whether or not they are valid, old timers will agree that complaints must be answered. They cannot be ignored even if the complainer is complaining of flies or fleas.

EDITORIAL SECTION

Under date of August 1, two communications, one from Harry Stage and one from the AMCA Membership Committee, were sent to each of the 250 mosquito abatement agencies in the United States.* The points discussed are so timely and significant that all AMCA members should read them. They are reprinted herewith as the editorial section.—D. L. C.

At the Chicago meetings of the American Mosquito Control Association last March, Mr. E. J. Stansfield, Manager, Greater Winnipeg Anti-Mosquito Campaign of Manitoba, Canada, gave a very interesting paper, "Red River Flood Aftermath," in which he described the decontamination work of their mosquito control district during the flood disaster. The work of the Winipeg Mosquito Control Agency made us all proud of their accomplishment. It was a fine example of how well-trained men familiar with effective equipment were instantly available with the needed "know how" to relieve their community's distress.

If you are confronted with an emergency of equal degree, for example, an enemy air attack, are you ready to meet it? Do your men know their job—their responsibility—and do they have the proper equipment instantly available?

Many mosquito abatement agencies in the United States have already contacted their local Civil Defense agencies and are taking an active part in the planning program to meet national emergencies. Perhaps the Civil Defense agencies in your area would like to know of your local mosquito abatement district; of its men and available equipment. It is possible they might be able to cooperate in furnishing your district with suitable spray or fogging equipment so as to have it surely available and manned by trained operators in case of need. Perhaps here is an opportunity to provide and obtain mutual assistance: you furnish the "know how," the Civil Defense agency furnishes the equipment.

If the Civil Defense agency wishes to purchase fogging equipment for adult mosquito control they may wish to use military specifications. As far as we have been able to determine, there is only one specification now available for fogging equipment (MIL–A–898A: November 1950), furnished Civil Defense agencies by the Bureau of Supplies and Accounts, U. S. Navy Department, Washington 25, D. C. Additional specifications are now in the making which will permit the purchase of a number of fogging and misting machines.—H. H. STAGE.

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

334 Rowell Bldg., Fresno, Calif.
August 1, 1951.

To All Mosquito Control Agencies:

The American Mosquito Control Association is a non-profit organization, engaged continuously in activities leading to more and better mosquito control. Obviously it must use educational means as its primary vehicle to attain this end.

Every mosquito control agency now in existence and every mosquito worker, member of the association or not, has received some benefit from the work of the association. In exchange, all of the participating agencies or persons have contributed to its accomplishments, whether by supplying information resulting from original research or observation; by effort put forth in committee activity; or merely by the financial support provided by the payment of dues or subscriptions.

If you will critically review the program of your own agency, you will see immediately that its progress has largely resulted from the wise use by you of information which has come to you from others! Most of your knowledge of materials, equipment, and even the living habits of the mosquitoes you are fighting has been de-

* See *Mosquito News*, Vol. 11, No. 1, March 1951, for a list of mosquito control agencies.

veloped and contributed by others! But developments you have contributed may today or tomorrow be highly important somewhere in the world—perhaps in places so remote that you may never know the worth of your contributions.

It is in the exchange of information that AMCA contributes most directly to the practical work of mosquito control. But this means publication, and publishing costs are high indeed. The latest number of MOSQUITO NEWS cost for printing alone about $1400.00, approximately three times as much as the first all-printed number, which was distributed a few years ago! Even though all services are contributed by members and officers (there are no paid officers, no paid clerks or secretaries) the out-of-pocket expenses for printing, postage and stationery continuously tax the resources of the association, and limit the rate at which its publications can be increased in size and quality. Only by increasing its income can AMCA increase its services to mosquito control. This means more dues-paying members, more subscribers, and more advertisers.

Every member, every participating agency, is urged to accept a part of the responsibility for increasing the size and the prosperity of AMCA! If each one would consider himself part of the "volunteer membership and circulation committee" and get *just one new member,* the job would be done. Don't put this matter aside! Resolve instead to get your new member within the next 30 days! And remember—if you do not have a membership blank at hand, an application in letter form is equally acceptable.

President Rees has written: "Some mosquito control agencies have enrolled all their board members or commissioners, as well as their technical and supervisory personnel as members of AMCA. Others have not realized the value to their own local programs of utilizing this means of aiding the Board personnel to better discharge the responsibilities they assumed upon accepting appointment to a mosquito control agency. To have MOSQUITO NEWS coming regularly *to the home* of administrative officers provides a steadily increasing fund of information readily available for use when they have leisure time for reading. It also stimulates them in their work through the friendly contact provided by the NEWS, with other mosquito workers in remote places. Board Members and Commissioners make a personal sacrifice every time they desert their private business to give time and effort to mosquito control. The meetings of the mosquito control boards are usually so full of the immediate business of the organization that there is little if any time for anyone to present an account of what is being done elsewhere. A membership in AMCA and a subscription to MOSQUITO NEWS is surely but a small reward for a district or commission to provide each of its board members for their service to the community!"

MEMBERSHIP COMMITTEE.

AIRSPRAY BULLETIN STILL AVAILABLE

Inquiries have been received as to the availability of the AMCA's Bulletin No. 1 "The Use of Aircraft in the Control of Mosquitoes." This bulletin, which comprises 46 pages of text and 45 illustrations, is still available at $1.50 per copy. Orders should be sent to Mr. Thomas D. Mulhern, 334 Rowell Bldg., Fresno, Calif.

WHO'S WHO IN MOSQUITO CONTROL*

STANLEY B. FREEBORN, TRUSTEE, ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT
CALIFORNIA

An almost life-long interest in mosquitoes and their control certainly qualifies Stanley B. Freeborn to be a Trustee of a mosquito abatement district. Brought to California in 1914 as Instructor in Entomology in the College of Agriculture, University of California, he was at once in direct contact with the late William B. Herms, and no one could be associated with Bill Herms for any length of time without acquiring an intense interest in mosquitoes and their control. And although since that time Dr. Freeborn has acquired a wide variety of academic and non-academic interests, he has continuously maintained a high order both of productive scholarship and practical achievement in culicidology.

Stan was born at Hudson, Massachusetts, December 11, 1891, the son of Franklin King and Addie M. (Houghton) Freeborn. He was educated at Massachusetts Agricultural College, receiving his B.S. in Entomology in 1914, and the Ph.D. in 1924. In 1949 the University of Massachusetts conferred on him the honorary degree of Doctor of Science.

He married Mary B. Chase, March 15, 1917, and they had two children, Stanley B., Jr., and Joyce. Stanley Junior attended the University of California, and rowed in the varsity crew (1937 40). He is now a Commander in the United States Navy. Joyce married H. J. Jensen and lives in Berkeley. Mrs. Freeborn died in January 1946; in December 1949, Stan married Mrs. Marian G. Maclise.

In 1913–14 Stan was Deputy State Quarantine Officer for Massachusetts, and in 1914 he was called to the University of California at Berkeley as Instructor in Entomology. In 1918 he was promoted to Assistant Professor of Entomology, in 1925 to Associate Professor and Associate Entomologist in the Agricultural Experiment Station, and in 1933 to Professor and Entomologist in the Experiment Station. In 1935 he took on the added duties of Assistant Dean of the College of Agriculture and Assistant Director of the Agricultural Experiment Station, and has since continued in these capacities.

In 1918–19 he served as a Second Lieutenant in the Sanitary Corps, U. S. Army, and was engaged in malaria control work in the tidewater Virginia area. From 1919 to 1936 he held a reserve commission as Assistant Sanitarian and later Associate Sanitarian in the U. S. Public Health Service. In 1942–44 he was on active duty as Senior Malariologist and Director of Operations for Malaria Control in War Areas, USPHS.

Since 1947 he has been a member of the Vector Control Advisory Committee, and since 1949 Consultant in Entomology, to the California State Department of Public Health, and has taken an active interest in the epidemic virus encephalitis control problem in California, as well as in other insect transmitted diseases.

He has a wide range of interests, particularly in sports. For many years he has been the University of California representative on the Board of Directors of the Pacific Coast Conference. In 1949–50 he was a member of the Federal Water Pollution Control Board. He is a Fellow of the American Association for the Advancement of Science, and a Member of the Entomological Society of America, the American Association of Economic Entomologists, the American Society of Parasitologists, the Pacific Slope Entomological Society, Sigma Xi, Alpha Zeta, Delta Omega, etc.

Much of his mosquito lore he learned at first hand in the field. There is extant a motion picture showing Stan wielding a shovel to dig a ditch to drain a mosquito producing pond. He accompanied Professor Herms on many of his field surveys and collection trips throughout California. He has taken an active interest in the California Mosquito Control Association, and has contributed several valuable papers at its meetings. His scientific writings in the field of Entomology are extensive.

On the death of Professor Herms in 1949 the Berkeley City Council appointed Dr. Freeborn to succeed him as a Trustee of the Alameda County Mosquito Abatement District.—H. F. G.

* Who are some of the men who act as commissioners and trustees? This is the first of a series of articles on the men who occupy the important posts in mosquito control work.

REVIEWS AND ABSTRACTS

Rice Field Mosquito Control by Pellet-Borne Insecticides. By F. E. Whitehead. Published and distributed by the Agricultural Experiment Station, University of Arkansas College of Agriculture, Fayetteville, Arkansas, 1951. This pamphlet reports on extensive experiments carried on by the author in the use of pellet-carried insecticides in the rice fields of Arkansas for the control of *P. discolor* and *P. confinnis,* they being the dominant species.

Conclusions of these experiments were:

1. Penetration of the foliage was an important factor and the pellets being heavier than sprays or dusts were better able to reach the water where the insecticide would be released by the dissolving of the pellet.

2. Applications made after mosquito larvae were present were more effective than applications made previous to hatching.

3. The pellet form of carrier is inexpensive, easy to prepare, has excellent handling qualities, stores well, and small dosage required (approx. 2 lbs. per acre) is economical to apply by airplane.

4. Dieldrin was more toxic and retained its toxicity better when exposed to weathering in the field than the other insecticides, although DDT was effective when used in the water where larvae were present.

This bulletin contains very valuable information for anyone connected with mosquito control in rice-growing areas.—Thomas M. Sperbeck, Mgr. Sutter-Yuba Mosquito Abatement District, Yuba City, California.

A Bibliography on the Relations of Mosquitoes to Vegetation in the Eurasian Arctic and Subarctic. By Rev. Artheme Dutilly. Environmental Protection Section, Report No. 162. Research and Development Branch, Military Planning Division, Office of the Quartermaster General, 1950. The bibliography has been prepared by the Rev. Artheme Dutilly of Catholic University. It is an unique list of 408 publications concerning the breeding habits, control, and relationship of the environment to mosquitoes in the Eurasian arctic and subarctic. In the back of the report is a list of 240 scientific names of mosquitoes that appear in the citations.

Most of the references are not available to mosquito workers and are in languages such as Scandinavian, Finnish, and Russian which are not ordinarily read by American workers. The report is in two parts, 128 references other than Russian and 280 Russian references. A special effort was made to list all references for 1930 to 1949 and those of unusual importance prior to 1930. A general abstract of the subject-matter is included with most of the citations.

Although the citations do not strictly follow the title, they constitute an important contribution to our general mosquito information; and of course, emphasis is given to the environmental relationships. It is most helpful in summarizing mosquito work that is being conducted in Eurasia. The report is processed and therefore is not as available as one appearing in a standard periodical.—B. V. Travis, Cornell University Agricultural Experiment Station, Ithaca, N. Y.

The Mosquitoes of California. Bulletin of the California Insect Survey, University of California Press, Berkeley, Calif., 1(2):25–78. Stanley B. Freeborn and R. M. Bohart, 1950. Price, 50 cents. This paper is a "must" for anyone studying Californian or West Coast mosquitoes. It will also be very useful to anyone studying mosquitoes elsewhere in the United States. It includes keys to adults, larvae and males of 41 species of mosquitoes occurring in California. The discussion of each species includes notes on biology and distribution, separation from closely allied species, and a listing of accepted California records. The keys include many new taxonomic characters, particularly in the genus *Culex.* The authors have presented good characters separating such closely allied species as *Culex apicalis, boharti, reevesi* and *territans* in the subgenus *Neoculex;* and *thriambus, erythrothorax* and *restuans,* and *tarsalis* and *stigmatosoma,* in the subgenus *Culex.*

The distribution records included are not complete for California. To quote the authors: "Unless otherwise stated, we have included only records for which we have been able to see the actual specimens personally. Existing published records of well-qualified investigators are not always trustworthy, largely because of nomenclatorial changes caused by a more complete understanding of the mosquito fauna."

A large table is presented in which county records of California mosquitoes are listed alphabetically by counties and by genus and species of mosquitoes. Those counties from which the authors have examined specimens are marked with an "X". Those counties where a record exists in the literature are marked with ".". Plates 2 through 8 illustrate important taxonomic structures of the larvae or male used in identifying mosquitoes. The excellent drawings in plates 7 and 8, showing details of *Culex* larvae and male genitalia, are distinct contributions to the literature on North American mosquitoes.

The booklet has been printed by the offset method on 8½" x 11" paper making it somewhat larger and more cumbersome to use than bulletins of the usual size.—Harry D. Pratt, Communicable Disease Center, Atlanta, Georgia.

Observations on Mosquito Behavior in Native Huts. A. B. Hadaway. Bull. Ent. Res. 41(1):

63–78. May 1950. Mosquitoes continue to enter occupied, untreated native huts throughout the night, with peak periods of entry at dusk and dawn. Early morning mosquito catches do not give a true picture of the numbers entering and leaving huts during the night. In a series of catches 63 per cent of 5,576 mosquitoes and 79 per cent of 506 *Anopheles gambiae* were caught resting on the underside of the thatch roof. By using 5 traps inserted in apertures one foot below the top of the wall, the numbers of mosquitoes attempting to leave a hut were determined. Of 1,014 mosquitoes entering huts before 10 p.m. 63 per cent remained inside until 6:30 a.m., that is, for 8½ hours. Catches to estimate numbers entering and leaving at different times during the night were also made.

Treatment of huts with DDT wettable powder and DDT-kerosene solution did not interfere with the normal behavior of mosquitoes as far as entry was concerned. Biting occurred in the treated huts. The DDT wettable powder appeared to be more effective than the DDT-kerosene solution.

Some mosquitoes entered the treated huts, fed and then left before acquiring a lethal dose. After making contact with treated surfaces, mosquitoes became restless but, under the conditions existing in the huts during the experiments, activation did not result in more leaving the treated huts than the untreated one. Unfortunately there were few *A. gambiae* and the predominant species entering the huts was *Taeniorhynchus fuscopennatus.*

Some of the female *A. gambiae* released into unoccupied DDT-treated huts escaped into the traps before acquiring a lethal dose. Although there was a tendency for more to enter the traps of a DDT-treated hut than those of an untreated hut, the data are insufficient to show a significant difference.

The majority of mosquitoes entering the traps did so within one hour of their release. No mosquitoes were still alive 12 hours after their release in huts treated 17 weeks previously with DDT wettable powder or DDT-kerosene solution, or in the hut treated 12 weeks previously with "Gammexane" wettable powder.—Author's summary.

(Editor's note: The above research is reported from Uganda, Africa.)

SOBRE A CAPTURA DO "ANOPHELES DARLINGI" E DO "ANOPHELES ALBITARIS" NAS PAREDES EXTERNAS DE CASAS DEDETIZADAS EM ENGENHEIRO DOLABELA, MINAS GERAIS. (Concerning the Capture of *Anopheles darlingi* and *Anopheles albitarsis* on the Outside Walls of Houses Which Have Been Treated With DDT in Engenheiro Dolabela, Minas Gerais.) By Fernando M. De Bustamante, Olympio da Silva Pinto, Arino S. Guedes, S. H. Xavier, and J. R. Freitas. Rev. Brasileira Malariol. e Doenças Trop. 3(1):122–129. 1951. The finding of many specimens of *Anopheles darlingi* and *Anopheles albitarsis* resting on the outside of walls of a group of houses at Engenheiro Dolabela and Lagoa Grande, county of Bocayuva, State of Minas Gerais, is reported. The interior of the houses has been sprayed regularly with DDT since 1946–1947. The fact is discussed that *albitarsis* was found in greater quantities resting inside the DDT-sprayed houses than *darlingi,* although *albitarsis* is known to be less domestic and shows a lower density in the area than *darlingi.* Possible explanations for this occurrence are given.—Authors' summary.

COLLECTION OF CULICINE MOSQUITOES (DIPTERA, CULICIDAE) IN TAIWAN (FORMOSA), CHINA, WITH DESCRIPTION OF A NEW SPECIES. By C. Y. Chow. 1950. Quarterly Jour. Taiwan Museum 3(4):281–287. *Aedes (Finlaya) sinensis* n. sp. is described. During past four years' collection of culicine mosquitoes in Taiwan, 34 species belonging to 7 genera were found. Among them, 4 species: *Harpagomyia jacobsoni, Uranotaenia maculipleura, Armigeres (L.) omissus,* and *Aedes (S.) albolineatus* are new records to China: 3 genera: *Harpagomyia, Uranotaenia,* and *Orthopodomyia,* and 19 species belonging to the 7 genera are reported for the first time in Taiwan.—Author's summary.

DA APLICAÇÃO DE DDT APENAS EM FAIXAS PINTADAS NAS PAREDES INTERNAS DAS CASAS, EM ZONA DE TRANSMISSÃO DE MALARIA POR ANOFELINOS DO SUBGENERO "KERTESZIA": PRIMEIRAS PROVAS EXPERIMENTAIS. (The Application of DDT on Painted Stripes on the Interior Walls of Houses in the Zone of Malaria Transmitted by Anophelines of the Subgenus *Kerteszia:* First Experimental Tests.) By Rene G. Rachou and Milton Moura Lima. 1951. Rev. Brasileira Malariol. e Doenças Trop. 3(1):36–47. The anophelines of the sub-genus *Kerteszia, cruzii* and *bellator,* have a marked preference for resting on painted stripes of the walls; the rate of specimens resting on these stripes is about 80 to 85% of the total ones captured in the rooms which have the stripes. Based on this preference the authors applied a 5% DDT oil solution on the stripes of two rooms of a house (with 5 rooms) in Caiacanga (Santa Catarina); they reduced by 80.2% the mosquito density in this house. In 2 control houses of the same locality this density increased 80.4 and 158.3%. These preliminary results are encouraging and the authors suggest a test in a locality, applying the insecticide only on painted stripes of the walls of every house.—Authors' summary.

ATTEMPTS TO UTILIZE MOSQUITO LARVAE IN A BIOASSAY METHOD FOR INSECTICIDE RESIDUES IN ANIMAL PRODUCTS. By R. C. Bushland. 1951. Jour. Econ. Ent. 44(3):421–423. A method

of detecting insecticide contamination of milk and meat by bioassay with mosquito larvae is described. Tests were made with butter-fat containing one of the chlorinated hydrocarbon insecticides—DDT, TDE, methoxychlor, lindane, chlordane, and toxaphene — against fourth-instar larvae of *Aedes aegypti* (L.). Some constituent of emulsified butter-fat rendered all these insecticides nontoxic to the larvae. Treating butter-fat with sulfuric acid did not remove all the substances that interfered with the toxicity of DDT and TDE, but did eliminate the ingredient that reduced the toxicity of lindane. Toxaphene and chlordane were not sufficiently toxic to *Aedes aegypti larvae* to be detected by the method that was effective for lindane.

In the tests with beef fat it appeared that acid treatment of larger quantities of chlordane-contaminated beef fat might be utilized in a bio-assay with *Anopheles quadrimaculatus* larvae.—Author's summary.

Annual Report Malaria Eradication Scheme Mauritius. 1950. 25 pages. This report is the second annual report released by the Malaria Eradication Scheme on the Island of Mauritius. The direction of the scheme remains in the hands of Dr. M. A. C. Dowling who is ably assisted by a chemist, an entomologist, and a group of field officers. The scheme is under the general direction of C. B. Symes, Officer in Charge of Colonial Insecticides Research. It was originally devised to determine whether *Anopheles gambiae* and *A. funestus,* introduced from Africa about 100 years ago, could be eradicated from the island by DDT and BHC residual sprays. The use of benzene hexachloride residual sprays was abandoned in 1949.

Apparently *A. funestus* has been eradicated but in view of the less pronounced effect of DDT on *A. gambiae,* it was decided to utilize "Malariol," high spread larvicide containing DDT, in a more strenuous effort at species eradication. A total of 48,090 houses were sprayed during 1950 with 75,852 gallons of DDT wettable powder and DDT kerosene.—H. H. Stage.

Annual Report of the Malaria Division, Trinidad Government, British West Indies, 1950. 57 pages (processed). We were much interested again in seeing this annual report on work which was carried out under the direction of Dr. H. P. S. Gillette, Malariologist, and so ably assisted by Major R. A. Senior White, Entomologist, and Dr. F. R. S. Kellett, Medical Officer of the Malaria Division, Health Department of Trinidad and Tobago. Evidence that the work was ably directed is contained in the statement that, "there has been no epidemic of malaria in any part of the colony of Trinidad and Tobago during the year and there was an appreciable fall in malaria transmission." It was noted that DDT was effective against *Anopheles aquasalis* for 8 months whereas under similar conditions Gammexane lasted 14 weeks. The control of mosquitoes still presents serious obstacles in rice and vegetable patches. Drainage is inadequate and oil cannot be applied in sufficient concentration. The use of high spreading oil with DDT is sometimes satisfactory but an insufficient staff makes regular treatment impossible. There were 14,957 homes treated with DDT residual sprays in Tobago and 23,795 in Trinidad during the year. The *Aedes aegypti* problem was surveyed and of 19,088 premises inspected, 3,441 were found to have been breeding in containers. Control operations against *A. aegypti* were begun in December 1950.—H. H. S.

Lutte Antipaludique par les Insecticides a Action Remanente. Résultats des grandes campagnes. By Dr. E. J. Pampana, Chief, Malaria Section, World Health Organization. World Health Organization: Monograph Series, No. 3, 72 pp., price 5/–, $1.00, Sw. fr. 4.00. A study by Dr. Pampana entitled "Lutte antipaludique par les insecticides à action rémanente" has just been published as No. 3 in the Monograph Series of the World Health Organization. Since the discovery of residual insecticides, such as DDT and HCH (hexachlorocyclohexane or BHC), malaria control has developed considerably throughout the world. In several countries where it was an historic scourge, malaria has ceased to be a public-health problem. This is the case, for instance, in Italy, Greece and Argentina.

In this well documented study, Dr. Pampana reviews the various malaria-control campaigns in progress in some thirty countries in four continents, the often dramatic results of which have been communicated to the World Health Organization. In general, they have been followed by a marked decline in malaria endemicity shown by a fall in the morbidity and mortality rates for this disease or by a fall in the malaria indices.

The information on dosages of insecticides used, period of treatment, number of persons or habitations protected, and cost of control per head of population will be useful to health authorities and all those taking part or interested in modern methods of malaria control.

This general survey is the first document based on statistical data to give a picture of the success of malaria control using residual insecticides on a world scale. In it can be followed the gradual regression of a very deadly endemic disease. This study will certainly be read with interest by all those concerned with problems of public health.—WHO Review.

Malaria in Equatorial Africa. Report on the WHO Malaria Conference in Equatorial Africa. World Health Organization: Technical Report Series, No. 38, 72 pp., price 3/6, $0.45, Sw. fr. 1.80. (Available also in a French edition.) The report on the Malaria Conference in

Equatorial Africa is now available as No. 38 of the World Health Organization: Technical Report Series. This conference, held at Kampala, Uganda, under the joint auspices of WHO and the Commission for Technical Co-operation in Africa South of the Sahara, brought together experts on malaria from all parts of the world. The report on their discussions gives a comprehensive picture of the prevalence and effects of malaria on the continent of Africa and suggests methods for the control, and possible eradication, of what an earlier conference termed an "insidious" disease.

Among the subjects treated in this report are: (1) the general distribution and prevalence of malaria in Africa, and the morbidity and mortality which it causes; (2) the species of plasmodia and characteristics of their strains, *Plasmodium falciparum* being named as the parasite most widely and evenly distributed throughout Equatorial Africa; (3) the species and subspecies of the vectors, including their bionomics; (4) hyperendemic malaria and its relation to immunity; (5) the economic importance of malaria in Africa; (6) methods of malaria control; (7) therapeutics; (8) research on malaria in Africa, including a list of the malaria-research projects now in progress; (9) organization and training of malaria-control personnel; and (10) international planning for malaria-control in Africa. Annexes to the report give suggestions for uniform reporting of field research in malaria control and a list of the conventional symbols for the representation of anopheles of the Ethiopian region.

Among the conclusions of the conference that may well re-shape public health policy in Africa south of the Sahara, are two on which agreement has been achieved between two contrasting schools of thought: first, the advisability of carrying out malaria control even in areas where the adult population has developed tolerance against the disease; and, secondly, the efficiency of residual-insecticide methods in controlling African malaria.

In addition to presenting valuable technical information, the report on the Malaria Conference in Equatorial Africa shows the importance of international cooperation in large-scale malaria-control programmes. For, as Sir John Hathorn Hall, Governor of Uganda, pointed out in his opening address: "Where there are no natural boundaries preventing the spread of an insect-borne disease, its eradication from a continental area will clearly require the most coordinated form of human effort."—WHO Review.

SUMMARY OF THE ANNUAL REPORT OF THE SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT FOR 1950. Don M. Rees, Board of Trustees Publication. 1951. This report is a summary of the twenty-first annual report of the Salt Lake City Mosquito Abatement District. The report contains an account of the 1950 mosquito abatement program including: entomological investigation conducted by the Department of Invertebrate Zoology and Entomology of the University of Utah; the report of Robert A. Wilkens, Manager of the district; and a report on the audit conducted by Lincoln G. Kelly and Company, Auditors. News items include a review of the third annual meeting of the Utah Mosquito Abatement Association, held at Weber College, Ogden, Utah, on February 17–18, 1950. Proceedings of the meeting were prepared and are available on request.

The 1950 program was a continuation of the revised methods initiated in 1949. After this year's trial the 1950 program was conducted on (1) an expansion and intensification of the inspection and treatment program in the controlled area, (2) an increased flexibility of daily work assignments of the field personnel to provide for the necessary labor requirements to insure the most effective control under constantly changing field conditions, and (3) the control program to be directed more specifically toward preventing large broods of *Aedes dorsalis* from emerging and migrating into the city. This program was adhered to throughout the seasons with very satisfactory results.

Light traps were operated in Salt Lake City each Tuesday and Friday night from May 29 to October 27, 1950. Each trap was operated for approximately forty nights. Comparisons of the average number of mosquitoes collected in each trap per night are made with the past five years beginning in 1945. The average in 1950 was 3.8, a total average lower than in any year since 1942. *Culex tarsalis* was the dominant species collected during 1950, constituting over 50 per cent of the total number collected. *C. pipiens* and *Aedes dorsalis* represented approximately 45 per cent with *Culiseta inornata* and *A. vexans* completing the list.

Accomplishments list a description of mosquito source treated and the number of inspections and fish planted, larvicides used and drainage. The report on cooperative drainage will be of interest to all mosquito workers. The Salt Lake M.A.D., Salt Lake City and Salt Lake County contribute an equal sum of money for this purpose. Funds are administered by a committee composed of representatives from each group. This committee approved expenditures of $29,387.08 for dredging, leveling and filling.—T. G. Raley, Consolidated Mosquito Abatement District, Selma, Calif.

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